DISCOVERY

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

It Has Happened

WILL it come off? The editorial in the September 1939 issue of DISCOVERY posed that question. It was answered on August 5, 1945; the shock the answer created was not one jot the less though dread had been so long deferred. To no one on this earth can the news of the dropping of the first atomic bomb on Hiroshima—a major military supply depot and a city that had on August 4 some 300,000 inhabitants, have come as a relief from suspense.

Technical details were scanty. The initial announcement stated that the atomic bomb is more powerful than 20,000 tons of TNT and gives 2,000 times the blast of the largest of pre-existing bombs. We were told that uranium is the basic material, and hence those with some knowledge of atomic physics concluded that the aim of making the disintegration of the uranium atom self-accelerating had been achieved. Further technical information will have been released after this issue has gone to press; we hope to be able to publish a comprehensive article next month.

The paucity of facts did not prevent immediate and abundant discussion about the social and economic repercussions that would follow the harnessing of atomic power to constructive ends, an achievement which lies over the horizon, however. But as this note is being written very little enlightenment on the subject is being given to the public. One of the clearest leads has fittingly come from the president of the Royal Society, Sir Henry Dale, in a letter to *The Times*. The most important point he made is worth quoting in full.

"This achievement, at all stages, has been the greatest of war secrets", wrote Sir Henry, "kept with a magnificent loyalty. The scientists concerned will remain loyal to that duty, guarding closely whatever has still to be kept secret till the war with Japan is finished. Then, I believe, they will all wish to be done with it for ever. We have tolerated much, and would tolerate anything, to ensure the victory for freedom; but when the victory has been won we shall want the freedom. I believe, further, that the abandonment of any national claim to secrecy about scientific discoveries must be a pre-requisite for any kind of international control, such as will obviously be indispensable if we are to use atomic energy to its full value and avoid the final disaster which its misuse might bring. If it be objected that this would be incompatible with military secrecy of any kind, I should be bold enough to ask whether that is not already useless. If armaments are to be used only for the international policing of aggressors, what use have we for national secrecy?"

Periodically wavelets of public revulsion arise against the evils that come from the coupling of advanced scientific techniques with man's capacity for inhumanity. The wavelets are likely to grow to a tidal wave in the coming months and, judging from his whole letter, the possibility of this happening was anticipated by Sir Henry Dale.

Prospects of developing industrial uses for atomic energy will result in the great encouragement of research and development in this sector of science and technology. It is to be hoped that the study of the social relations of science will be accelerated at an even faster pace, and also the study of the social sciences. An atomic bomb is an ugly weapon in the hands of mankind with hundreds of complex social and economic problems receiving inadequate attention. Atomic power can be a different story if these problems receive the urgent priority now clearly imperative.

A New Means of Destruction?

SOME physicists think that, within a few months, science will have produced for military use an explosive a million times more violent than dynamite.

It is no secret; laboratories in the United States, Germany, France and England have been working on it feverishly since the Spring. It may not come off. The most competent opinion is divided upon whether the idea is practicable. If it is, science for the first time will at one bound have altered the scope of warfare. The power of most scientific weapons has been consistently exaggerated; but it would be difficult to exaggerate this.

So there are two questions. *Will* it come off? How will the world be affected if it does?

—from Discovery's editorial, September 1939

The Utilisation of Solar Energy

THE DAILY MAIL for June 29 (and most other daily papers for that date) printed the story of an interview with a SHAEF official, an American lieutenant colonel, who was describing German war inventions. He is quoted as saying: "It is accepted that at 5,100 miles above the earth's surface the force of gravity is neutralised. In 50 or 100 year's time access may be gained to this region, and it would be possible to place space stations there which would just remain put where they were. These could be used in the first place by astronomers and scientists. Then enormous sun reflectors three miles square could be established which would reflect the sun's rays to receiving stations on the earth's surface, probably off the shores of the Continent, which would generate enough steam to create all the electric power needed by Germany. A third development would be a terrible thing, according to the German scientists. Reflectors would form a weapon powerful enough to obtain control of the world. The military potentialities of this weapon would be illimitable. Focussed on a man it would kill him immediately. Ocean waters would burst into steam, forests would be instantly kindled and cities wiped out."

Congratulations must be offered on the timely revelation of these secrets to the public. They could be the more hearty if a few modifications were made in the text of the statement. It is not accepted that the force of gravity is neutralised 5,100 miles above the surface of the earth: space stations would therefore not stay put. Sun reflectors three miles square could not be established: they would not generate enough steam to supply all the electric power needed for Germany: it is not a feasible method for obtaining control of the world. With sufficient ingenuity a large pond might be converted instantaneously to steam: a few nearby woods might be damaged and slight inconvenience cause to a fair sized village.

It is a pity that so sensational a story was not verified before being put into print. If we omit the wildcat scheme for establishing space stations there does emerge, however, a serious point for discussion, namely the utilisation of solar energy for terrestrial purposes. If a surface of one square centimetre were placed outside the atmosphere of the earth, facing the sun, it would receive in each minute an energy of just less than two calories. The calorie is the scientific unit of heat energy, and means the energy required to raise the temperature of a cubic centimetre of water through one degree centigrade. The actual energy received on any considerable area is fairly large. For example the energy impinging on a surface of a square kilometre (about two fifths of a square mile) is equivalent to the steady production of about two million horse-power. If all this energy could be put to boiling water it would vaporise a cube of water about ten feet in side every minute. The energy falling on nine square miles would vaporise about twenty times as much water in a minute. This is not a particularly large body of water and already makes statements about oceans bursting into steam look rather silly. Even so there is a very big "if" involved. This quantity of water could be vaporised only if all the energy could be utilised.

In the first place the energy has to get through the atmosphere of the earth. According to Dr. Charles G. Abbott, late secretary of the Smithsonian Institution, who is the acknowledged authority on the utilisation of solar power, and who describes recent developments in the Annual Report of the Smithsonian Institution for 1943, clouds reflect about 75 per cent of the sun's energy, while in humid climates the water vapour in the air absorbs from 15 to 25 per cent of the solar energy.

London's least cloudy month is September with an average obscuration of 60 per cent, and Berlin is only slightly better off. This reduces the average energy received on the surface of the earth to half or less of the energy received at the top of the earth's atmosphere. If in addition we suppose that, say, 20 per cent of the solar energy is absorbed by water vapour when the sun is overhead at an altitude of 90 degrees, then, when the sun is at an altitude of 45 degrees, the absorption will be about 28 per cent. At an altitude of 30 degrees it will be 37 per cent, and at an altitude of 15 degrees, 58 per cent. In midwinter at noon in London, the sun is only about 16 degrees above the horizon: in spring and autumn the greatest altitude is about 39 degrees, and the greatest altitude ever attained, at noon in midsummer, is about 62 degrees. For seven months of the year the sun never reaches 45 degrees above the horizon. It is therefore clear that in addition to cloudiness which will make the energy supply very intermittent, the aspiring solar power engineer in this country or in most of northern Europe has to cope with a sun whose energy is very severely reduced by absorption in the atmosphere for the greater part of the year. Conditions are such that we can at once write off the possibility of making any considerable use of solar power for between half to three quarters of the daylight hours in the year, even neglecting the effects of cloud.

The way in which solar power has been used has been by the construction of metal mirrors which are turned to follow the sun and which focus the sunlight on to a long thin boiler running along the focus line. They have had some success on a small scale in experiments made at specially selected sunny high altitude stations as near the equator as possible. A somewhat different system was employed in a plant (erected by Eastern Sun Power, Ltd., near Cairo), which has now been abandoned for some thirty years. For cloudless regions in the tropics the atmospheric absorption would be less than 30 per cent for six hours or more every day, using the same assumptions about absorption as for London. For the latitude of London these favourable conditions would obtain for six hours a day only for a few days around midsummer.

Even so, the method is a practical proposition only if considerable care and ingenuity are exercised in the design of the plant. The best overall efficiency for the conversion of solar power received into motive power for the generation of electricity is round about 16 per cent. If then we have a reflector a kilometre square, placed in a cloudless desert region, and we assume a 25 per cent loss for atmospheric transmission, we find a total energy received of one and a half million horse-power. Conversion to motive power at 16 per cent efficiency gives a usable output of 250,000 horse-power, falling to perhaps 100,000 horse-power if the design is less efficient. This is for a reflector area of a square kilometre, and taking practical considerations of the spacing of reflectors into account Dr. Abbott

gives a figure of 250 square feet of ground space as necessary for the generation of each horse-power.

The essence of the problem is to reduce the capital cost of installation to make the project worth while, and to design the apparatus so that it does not waste too high a proportion of energy by "going off the boil" during intermittent periods of sun. It seems doubtful yet whether it is a worthwhile proposition even in the most favourable climatic regions, but in time to come, when other power sources are becoming exhausted, solar power may become a very important supplement to other sources. One thing however seems certain: that is that an industrial nation in a temperate latitude can never hope to supply all its power needs from solar energy.

Medicine and the Cyclotron

LAWYERS often complain of the practice of legislation by reference where the final bill is no more than a series of alterations to clauses in other bills, whose import cannot be understood without a lot of literary research. One sometimes has the same feeling in reading scientific papers. It would make the literature too bulky to make every paper a summary of the whole state of the subject with which it deals, but some slight concession to this end though leading consequently to some degree of repetitiveness would often greatly enhance the value of a contribution. But every now and again we need the offices of a skilled expositor to give us a summary of the state of the subjects in which we are interested. He does a real service, for not only may he pick out important original contributions which we have missed, but he may also give us a broad sketch whose lines are clearer than our own vision of them.

One such summary article, entitled "Medical Uses of the Cyclotron", appeared recently (February 1945) in the *Journal of Scientific Instruments* and is an excellent example of its kind. In it Dr. F. G. Spear gives his colleagues in the world of physics a conspectus of advances in treatment and diagnosis rendered possible by the use of the cyclotron, and thereby provides them with an opportunity of bringing their knowledge to such a state that they may in the future be able themselves to render physical service to the medical world.

The cyclotron, it will be recalled, is a device for producing very high velocity charged particles such as are necessary for causing atomic disintegrations and nuclear changes, and was developed by Professor E. O. Lawrence and his co-workers at Berkeley, California. (An item about the cyclotron appeared in this notebook in October 1944, p. 290.) America has taken the lead in cyclotron work and has thirteen instruments working, with nine under construction, as against ten elsewhere, including three in England. The latest cyclotron at Berkeley is situated on an isolated hill top, has a magnet weighing 4000 tons and will produce particles of an energy of 100 million electron volts, giving a particle beam which it is expected will penetrate 140 feet of air. This latest giant will require very careful precautions to control its potentially dangerous radiations, and will include water protection tanks twenty-five feet thick.

By a happy circumstance the medical work connected with the cyclotron which is being carried out with a model begun in 1939 is under the direction of E. O. Lawrence's medical brother, J. H. Lawrence. This medical work is of various kinds, but the form which appeals most to the imagination is the use of artificially radioactive atoms for the general study of normal and pathological metabolic processes, and which in some cases also holds out promise for the development of curative methods. The function of the cyclotron is to manufacture, by transmutation of elements, radioactive isotopes of normal elements. The word "isotope" means a species of atom which is indistinguishable in its chemical behaviour from a normal atom except that the masses of the two atoms are different. Many of these isotopes are unstable and disintegrate radioactively in course of time into atoms of a different kind. Thus, for example, the normal sodium atom (of mass 23) units has two isotopes, both of which, as far as chemical behaviour is concerned, function exactly like normal sodium, but the one is of mass 22 and is radioactive with a half life of 3·0 years, while the other is of mass 24 and also radioactive, disintegrating with a half life of 14·8 hours.

The presence of radioactive substances can be readily detected by sensitive instruments, and, since radioactive sodium can be combined to form sodium chloride, or common salt, just as ordinary sodium can, the fate of sodium atoms taken into the body can readily be followed by determining in what organs radioactive phenomena are originating. In fact, this technique enables the investigator to put a "tag" on an atom and follow its adventures in the body. The results are often most surprising; for example, radio sodium, given to a patient as common salt by the mouth, can be detected in the finger tips within two minutes. Almost any other element can be manufactured in the form of a radioactive isotope, and the absorption of iron in cases of anaemia and of iodine in the case of thyroid disease have been studied.

One special field of relevance is in the treatment of cancerous growths in various organs. It is found that radio calcium and radio strontium are both taken up selectively in bone, and particularly in cancerous tumours of bone. Radio phosphorus on the other hand is taken up by bone, bone marrow, spleen, lymph nodes and liver and also by the class of cancers known as sarcomata. There seems also to be a fair possibility of treating certain blood diseases by radio phosphorus which has at least the merit of much greater convenience over the older technique of X-ray therapy.

Turning aside from the medical field to the field of biological research we find radio carbon used in the study of the metabolic processes of plants, a study which already has produced some startling conclusions and which is certainly going to be of the greatest importance.

A different technique of medical treatment of cancer by the cyclotron is offered by the use of neutron beams. Neutrons are particles of the same mass as the proton—the nucleus of the hydrogen atom—but having no electric charge. This lack of charge gives them a high penetrating power, for they are not deviated by electric forces due to atoms as are the charged particles. There may be a future for neutron beams in cancer therapy, but experiments so far are somewhat inconclusive, a fact which need cause no surprise since they have so far been used only in tentative trials on hopeless and inoperable cases.

To gain some appreciation of the truly epoch-making importance of the medical advances initiated by the

cyclotron reference must be made to the original and eminently readable article. Perhaps the best description of the work is contained in a quotation given by Dr. Spears: "Lawrence and his collaborators are providing medicine, biology and physics with agents that should revolutionise our knowledge of the structure of the world and everything that lives in it."

The Story of Dicumarol

THIS tale begins some twenty years ago on the prairies of North Dakota and the adjacent Canadian territory of Alberta, where cattle were suffering from a strange sickness. The characteristic symptom was uncontrollable haemorrhage; accidental wounds such as scratches from barbed wire and the surgical wounds of de-horning or castration commonly proved fatal. Local veterinarians at first thought that the disease was due to bacterial infection. The pioneer investigations of Schofield in Canada and Roderick in North Dakota soon showed, however, that this view was wrong. They showed, too, that the disease was not due to a nutritional deficiency. They eventually found that the disease appeared only when the cattle were fed on sweet clover hay which had been improperly cured and had spoiled in the stack. When the cause was recognised the disease became known as "sweet clover disease". If cattle or sheep eat such hay the clotting power of their blood is greatly diminished and severe haemorrhage, usually fatal, develops spontaneously. The disease can be cured in its early stages by withdrawing the spoiled hay from the diet and transfusing blood from normal cattle.

When it became evident that the disease was caused by a toxic substance present in spoiled hay the problem entered the field of biochemistry. Attempts were made to isolate and identify the poison. The solution of the problem was effected by a research team at the Wisconsin Agricultural Experiment Station as a result of investigations begun in 1934. In 1940 the toxic substance was identified, in 1941 it was synthesised and its remarkable effect on the clotting of blood has led to the introduction of dicumarol into medicine.

One of the earliest problems in the chemical investigation was the development of a biological method of assaying the anticoagulant, or *HA* (haemorrhagic agent). To understand the nature of the test something must be said about the normal mechanism of blood clotting. While the details are still to be established the general principles are known. At the site of an injury the blood constituent prothrombin, in the presence of calcium, is converted into thrombin. Thrombin reacts with another blood constituent, fibrinogen, to give fibrin, which actually forms the clot. In his pioneer work Roderick showed that the anticoagulant affected only one link in this chain of events. Its effect is to diminish the prothrombin of blood plasma and the extent of the reduction parallels the delay in the time taken for the blood to coagulate. The prothrombin level can therefore be measured by observing the time taken for a sample of blood plasma to clot. It follows that the *HA* content of different materials can be compared by feeding them to experimental animals (rabbits are used) and observing the effect on the prothrombin level of the blood plasma. (In practice it was found that the test was made much more sensitive if the plasma was diluted eight or ten times before taking the clotting time.)

Once this technique of biological assay had been perfected work on the actual isolation of *HA* could be attempted. It was found that the only practicable solvent for extracting *HA* from the spoiled clover was dilute alkali. This was unfortunate because this solvent also dissolves practically everything else in the hay except cellulose. By tedious and prolonged chemical manipulations, however, it eventually proved possible to separate the active substance from the very numerous impurities. In June 1939 the investigators at Wisconsin saw the first crystals of *HA*. Shortly afterwards 5·8 milligrams of pure crystalline material was isolated. Mass isolation was immediately started and it eventually proved possible to isolate on an average 60 milligrams of *HA* per kilogram of spoiled hay—roughly 0·002 per cent on a dry weight basis. In a period of four months a stock of almost two grams was accumulated and the chemical investigation could begin.

From the first there were good reasons to believe that *HA* was related to coumarin, the substance which gives new-mown hay and certain orchids their fragrance. Coumarin is used to scent cheap tobacco and is an ingredient of artificial vanilla and some perfumes. It was known that varieties of clover containing little coumarin did not become toxic on spoiling. When coumarin, itself harmless, was added to fresh hay and the latter was deliberately allowed to spoil it became highly toxic. It was eventually found, in 1940, that the molecule of *HA* consisted essentially of two molecules of coumarin linked by a molecule of formaldehyde. Its full chemical name is 3,3′-methylenebis (4-hydroxycoumarin) which is usually abbreviated, to the more handy name dicumarol. The substance is a white crystalline solid melting at 288° C.

Over 150 compounds related to dicumarol have now been synthesised and their effect on blood coagulation noted. Though a number have proved active, none yet discovered is as active as dicumarol itself. It was observed that anticoagulant activity was confined to those derivatives which could yield salicylic acid, or a related compound, on chemical degradation. Salicylic acid itself was then tested and proved to be 1/20th as active as dicumarol. From salicylic acid it is an easy step to acetylsalicylic acid or aspirin. Aspirin itself was found to have a definite haemorrhagic effect and it may be noted that for many years evidence has been accumulating that haemorrhage of the intestines is a symptom of aspirin poisoning. The medical profession has recently drawn attention to the dangers of the indiscriminate use of aspirin, one of the most widely used of all drugs. (In 1942 consumption in the United States totalled eight million pounds, or about one ounce per head of population.) To prevent possible alarm it should, however, be stated that the action of aspirin and salicylates is very much less than that of dicumarol itself and the drug is not dangerous when used in the quantities normally prescribed.

Dicumarol, like another anticoagulant, heparin, has proved of considerable value in medicine in preventing blood clotting.

(For further information on dicumarol, see *The Harvey Lectures*, 1943–4, p. 162 (Science Press Printing Company, Lancaster, Pennsylvania) and *Nutrition Reviews*, February 1945, p. 55.)

Soviet Science Gets Top Priority

AN IMPRESSION OF THE 220th ANNIVERSARY OF THE ACADEMY OF SCIENCES

Professor V. GORDON CHILDE, F.R.S.E.

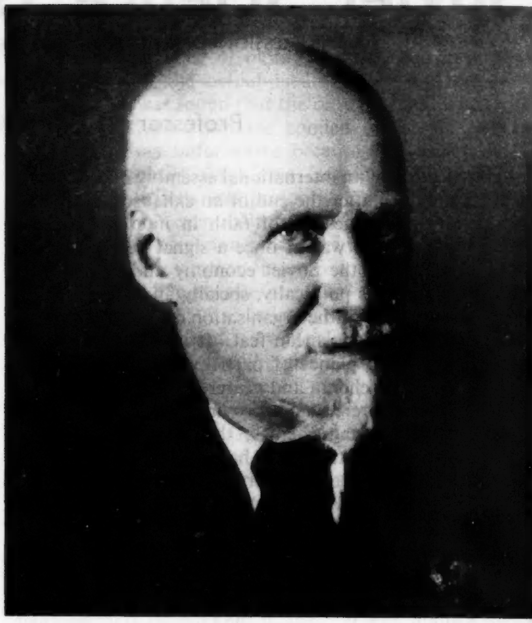
THE convocation of an international assembly of celebrated scientists a month after the end of an exhausting war was itself a magnificent gesture of faith in international co-operation. To me it was at once a signal demonstration of the resilience of the Soviet economy and of the high status science enjoys politically, socially and economically within the Union. For the organisation of such a gathering at this juncture was no mean feat. It involved the transportation in Soviet planes of participants from London, Paris, Fairbanks, Teheran and nearer capitals, the housing and feeding of foreign and provincial guests in over-crowded, bomb-damaged cities, the running of special trains over lines that the Nazis had deliberately wrecked, and the provision of fleets of cars. The provision of these services alone would be an indication of the attitude of the Soviet Government towards science and international co-operation therein. The same attitude was illustrated again by the participation of high members of the Federal and local governments in the sessions and the presence of Stalin, Kalinin and Molotov at the farewell State banquet in the Kremlin. Popular endorsement of this attitude may be inferred from the prominence given to the Academy's Jubilee in the Press: a good third of *Izvestia* and of *Pravda* was devoted to reports of sessions and cognate items illustrated with photographs.

The success of the gesture may be inferred from the number and distinction of the foreign scientists who managed to accept the invitation at short notice and at a time when so many were preoccupied with urgent problems of national reconstruction in addition to their normal academic duties. Seventeen nations, from Finland and Sweden to Bulgaria and Yugoslavia, from the U.S.A. and Canada to India and Iran, were represented by celebrities of the order of Shapley, Jolliot, and Szent Györgyi. And of course the Soviet Union itself embraces many nationalities; Yakuts and Uzbeks, Armenians and Esthonians brought greetings from local branches of the Academy or other institutions of higher learning, usually established in their territories only since the Revolution. Of course, while the Akademiya Nauk S.S.S.R. is the highest co-ordinating body for the whole Union, in accordance with the principle of complete cultural autonomy, similar academies have been recognised (as in the Ukraine) or have been established (as in Azerbaijan and Kazakstan) to perform this function in the constituent Republics. Moreover, archaeology, history and linguistics now stand under the aegis of the Academy, the former Akademiya Istoriy Materialnoy Kultury (G.A.I.M.K.) having become an Institute of the Academy (I.I.M.K.). Medicine, on the contrary, has separated off under the newly established Academy of Medicine.

For over a fortnight the representatives of the sciences, numbering over 2,000, attended formal sessions and exchanged information in sectional meetings and informal discussions in the various institutes, laboratories and museums where constructive research is carried out. The formal sessions were few and were occupied mainly with the presentation of addresses and with the delivery of papers by distinguished, but generally aged, academicians—papers of a general and historical character in the tone set by President Komarov's opening address (summarised in the July issue). These reflected an earnest desire for closer co-operation with colleagues in the West which was emphasised by an appeal—in English—for concrete suggestions to this end by Kapitsa at the closing session in Moscow. This was supported by the grave words of Jolliot to the effect that if scientific discoveries were to be kept national or commercial secrets, the doom of humanity was sealed—words not to be dissociated from the abrupt depletion of the British delegation by governmental fiat. But naturally in such an unwieldy assembly concrete results could hardly be achieved. In the more intimate sectional meetings and personal discussions positive progress was made in re-establishing contacts interrupted by six years of war and in establishing new ones. Our Soviet colleagues were eager to learn what was being done beyond the Union's frontiers and equally eager to show and explain what they themselves were engaged upon. The Academy's guests had every facility for visiting institutes and research stations of all kinds and of seeing whatever interested them there.

At the same time the gathering demonstrated—and was designed to—that in scientific collaboration with the West, Soviet science will not be a passive recipient. The papers read and the exhibitions organised were calculated to justify our colleagues' pride in the achievements of Russian science in general and of Soviet science in particular, including those of the smaller nations within the Union. The most profound impression made upon all delegates was the high status enjoyed by science in the eyes of the Soviet State and of the great masses of its citizens. This is positively expressed in the reservation of scientists (including, of course, archaeologists) during the war and in the high priorities evidently enjoyed by scientific institutions in repairs to damaged fabrics, in supplies of material and in paper for publications. Even in archaeology, liable to be less favoured than sciences making more direct contribution to increasing supplies of guns and butter, the State Historical Museum in Moscow has already been reinstated and is open to the public who crowd in; in the Anthropological Institute of the University specimens and apparatus are being reinstalled in newly repaired premises. Moscow and Leningrad publications, suspended during the war (important books have been appearing in Georgia and other Republics), are going to press. Expeditions engaged in excavations or ethnographic and anthropometric surveys were already in the field or about to leave.

The fact is that pure and applied science offers the individual in the U.S.S.R. the opportunities for social and economic advancement here provided by business or law. Academicians, along with generals and leading



Academician Vladimir Komarov, who has just resigned from the presidency of the Soviet Academy of Sciences. Aged 75, Academician Komarov ranks as one of the world's leading botanists. He was responsible for starting the monumental *Flora of the U.S.S.R.*, which already runs to many volumes though it is not yet complete.

artists, enjoy, in addition to the personal satisfactions and academic dignities that reward such workers everywhere the social prestige reserved to successful financiers, hereditary landowners, ecclesiastical dignitaries and legal luminaries in Britain, and many of their material advantages too—the best flats, extra rations, motor-cars. As a result the pick of the youth of all classes is attracted to science. Whatever the average standard of these recruits, from such vast numbers a really substantial proportion of first-class workers is only to be expected. Physicists in particular were impressed by the numbers of post-graduate students engaged in advanced research in the institutes of Moscow and possessing already the very abstruse equipment requisite therefor. But the multiplication of competent research students, remarkable in this domain owing to the peculiar difficulty of the prerequisite qualifications, is equally conspicuous in all branches of knowledge.

Two practical corollaries follow. For a research worker in any domain a reading knowledge of Russian is indispensable—and after all not too difficult to acquire. Our Russian colleagues have indeed been, and intend to be, generous in providing English or French summaries of all important reports. But a summary can never suffice the real student who wants to know not only conclusions, but also the precise observations on which these are based; moreover, one can hardly expect detailed and exact accounts of, say, a breeding experiment or an archaeological excavation to be translated *in extenso* and accurately every time. Secondly, the Atlantic countries can hardly expect to maintain their present technical superiority unless they can offer like inducements to their scientists.

There seems to be a certain tendency to transfer advanced research from the universities to separate Institutes, directed by academicians or under the immediate control of the Academy or its branches in the Republics. This, while relieving the researcher of the burden of teaching and the more serious attendant worries of examination and administration, might tend to reduce the Universities more to the level of technical colleges, though they would presumably remain indispensable recruiting grounds for the staffs of the institutes. Be that as it may, I see no evidence that the barriers between the several sciences have been heightened. On the contrary, Russian archaeologists seem to have been more uniformly successful in securing the requisite collaboration of geologists, botanists, zoologists and chemists than their British and American colleagues, to quote one instance.

In the recruitment of its prospective members the Academy plays its part by publishing, or arranging for the publication of, elementary but authoritative text-books on the several sciences. An exhibition of its publications organised in the Academy's "Fundamental Library", under the title *Akademiya Nauk through 220 Years*, emphasised this side of its activities. A point was made of "propaganda to diffuse scientific thinking among the widest masses of our nation." In the section devoted to social sciences I happened to notice two excellent histories for middle schools, *The Ancient World* (1943), and *The Middle Ages* (1945), as well as many books for higher grades like an *Outline of the History of Technique in the Ancient Orient*, edited by Academician Struve. I may remark that books are still very cheap and the numerous bookshops are well stocked with scientific books and manuals, whereas escapist literature is not displayed in the windows nor on the counters. Incidentally, shops selling scientific instruments are remarkably conspicuous in Moscow.

The coordinating role of the Academy may be illustrated from archaeology, as I happen to be an archaeologist. The principal union body for organising and financing research—in the form of excavation—is the Institute for the History of Material Culture (I.I.M.K.) of the Academy. It has branches in Moscow and Leningrad; archives, laboratories and collection in the latter city. From G.A.I.M.K. it has inherited the archives and some of the functions of the Imperial Archaeological Commission of Tsarist times. There is also an Archaeological Institute of the Ukrainian Academy and similar bodies function in Georgia, Úzbekistan and other Republics. Museums, notably the State Hermitage, the State Historical Museum (Moscow) and the State Museum of Georgia (Tbilisi), also organise expeditions or participate in those organised by I.I.M.K. But since the Revolution emphasis has very properly been laid on the educative rather than the laboratory functions of museums so that their staffs have less time for field work or writing excavation reports. In practice, excavations sponsored by museums are always expected to produce specimens

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Surface Tension and Splashes

Professor ALLAN FERGUSON, M.A., D.Sc.

"WATER finds its own level." This somewhat vaguely stated hydrostatic truism is illustrated in the level surface of any pond at which we care to look; but it is, at first sight, contradicted when we dip a glass tube of, say, a millimetre bore vertically into the water, for we find that the surface of the water in the tube stands some three centimetres higher than the level of the horizontal surface of the water outside.

What is the reason for this apparent paradox? A few simple experiments and observations show that the phenomenon of capillary rise is not an isolated one, and that there is a force existing at the surface separating a liquid from air (or at the surface of separation of two immiscible liquids) which may, on occasion, give rise to very striking effects, and indeed to results of very great industrial importance. Moreover, the theoretical consideration of these forces leads us straight to very fundamental problems of cohesion—problems illustrated by Sir Oliver Lodge when, lifting a long pointer which was lying on the lecture table, he posited the problem, "why, when I lift up one end of this rod, does the other end come up?"

To return to our simple experiments: a thin disk of copper, slightly greased, will float on the surface of water, in apparent contradiction of the principle of Archimedes; similarly, if the wires of a small sieve are thinly coated with paraffin wax (without plugging up the holes) the sieve will float on a water surface and, as Sir Charles Boys showed in a popular lecture course more than fifty years ago, the nonsense verse:

> "They went to sea in a sieve, they did,
> In a sieve they went to sea;
> In spite of all their friends could say,
> On a winter's morn, on a stormy day,
> In a sieve they went to sea,"

was not so nonsensical, after all!

The hairs of a small camel-hair brush, immersed in water, remain separate; withdraw the brush from the water, and the hairs cling together exhibiting the characteristic pointed tip.

Molecular Attraction

Such facts could be multiplied almost indefinitely. What common explanation underlies them?

If we admit the existence, between the molecules of a liquid, of forces of attraction, powerful at very small distances, but falling off very rapidly with increase of distance, we see that we can, in imagination, draw round any selected molecule in the liquid a sphere of very small radius—the so-called sphere of molecular attraction—such that all molecules within the sphere may be considered to exert an attraction on the central molecule, whereas molecules outside the sphere are too far away from the central molecule to exert any appreciable force thereon. If now, the central molecule selected for consideration is at a distance from the free surface of the liquid greater than the radius of the sphere of molecular attraction, it will be completely surrounded by molecules capable of attracting it; it will be pulled equally in all directions by its neighbours, and will, on the whole, experience no resultant force from their attractions.

It is quite otherwise if the central molecule is at a distance from the surface of the liquid less than the radius of the sphere of molecular attraction. Part of this sphere is now situated in the air above the surface of the liquid, and there are no liquid molecules in this portion of the sphere to contribute their quota to the attraction on the central molecule. It results, therefore, that the molecule will experience a force tending to urge it away from the surface and into the interior of the liquid, and this will be true for all molecules whose distances from the surface of the liquid are less than the radius of the sphere of molecular attraction. A very thin surface layer of the molecules of a liquid is therefore in a special condition, differing from that of molecules in the interior of the liquid, and it is only to be expected that, granted favourable circumstances, phenomena depending on the existence of this surface layer may be observed.

In particular, to bring molecules into the surface, work must be done against these forces. But to bring more molecules into the surface means an increase in the area of the surface. Hence to increase the area of the liquid surface demands the expenditure of work, just as to stretch a sheet of india-rubber demands the expenditure of work, and to this extent the surface of a liquid may be compared to a stretched elastic membrane. But the analogy must not be pressed too closely. The tension in a sheet of stretched rubber increases as the sheet is extended, whereas the tension in a liquid surface is independent of the area of the surface, save in very exceptional circumstances.

Across any line, then, drawn in the surface of a liquid there exists a tension, and the magnitude of the tension across a line of unit length is termed *the surface tension* of the liquid. It is measured in terms of force per unit length—dynes per centimetre or grams weight per centimetre, for example. The forces concerned are quite small—at ordinary temperatures the surface tension of water is about 72 dynes per centimetre, and a force of 72 dynes is about equal to a weight of one fourteenth of a gram, or one fourhundredth part of an ounce.

One important property of surface tension is its dependence on temperature. The surface tension of a normal liquid decreases with increasing temperature and becomes zero at the critical point*. That the surface tension of a liquid decreases as the liquid becomes hotter may easily be demonstrated by pouring a little water into a large

* If a thick-walled glass tube be taken, partly filled with a liquid, say ether, and closed at both ends, so that the tube contains only ether and ether vapour, then if the tube be gradually heated, as the temperature rises the liquid becomes less dense and the vapour more dense, until at a certain temperature—about 194°C. for ether—the two densities become equal and all distinction between the liquid and the vapour state disappears. This temperature is termed the *critical* temperature.

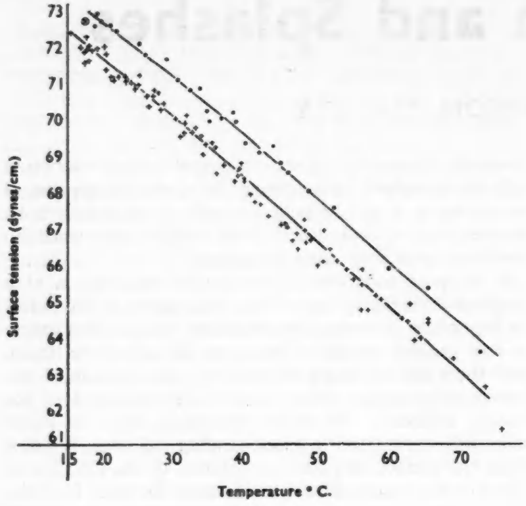


FIG. 1

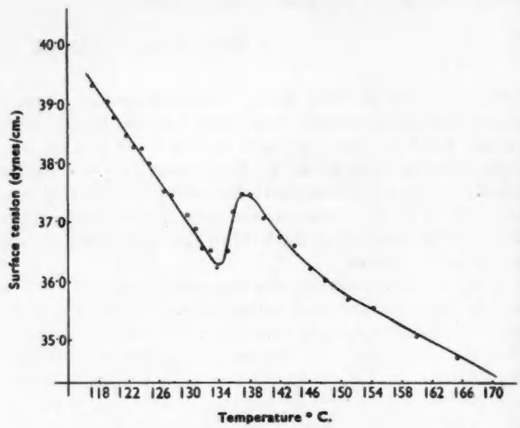


FIG. 2

shallow dish and dusting the surface of the water with lycopodium powder. If the tip of a heated soldering bit is held just above the water surface at the centre of the dish the lycopodium powder is swept to the sides of the dish by the pull of the greater tension in the cooler parts of the surface.

The way in which surface tension diminishes with increase of temperature over a limited range is illustrated in Fig. 1, which gives curves showing the relation between surface tension and temperature for ordinary water and for heavy water. The upper curve is the curve for ordinary water, the lower curve that for heavy water.

It may be noted here that this decrease of surface tension with increase of temperature is not quite universal. There are one or two rare exceptions over a very limited range. Certain solid crystals melt to turbid liquids which exhibit crystalline properties. These liquids, when heated, lose their crystalline properties at a sharply-defined temperature (the transition temperature) and thereafter behave as ordinary liquids. If the surface tension of such a liquid be measured at different temperatures, it is found that it decreases regularly with increase of temperature until the transition point is reached, when a marked increase of surface tension occurs in this neighbourhood. After the transition point is passed the surface tension again begins to decrease.

Fig. 2 shows the change of surface tension with temperature for the substance known as *para*-azoxyanisol.

Of the many common phenomena which depend on surface tension, the detachment of a drop from a slowly dripping tap and the splash of a drop of water falling into water afford singularly beautiful examples, though they are difficult—indeed impossible—to follow with the unaided vision. If we study closely the detachment of a drop of water from a slowly dripping tap, we are able to follow the initial stages easily enough. But at a certain stage, a "waist" begins to form on the drop, the process of detachment accelerates, and the final stages are rushed through at a speed which completely defeats any attempts of the unaided eye to follow them.

How may we slow down the process? Various suggestions have from time to time been made. Aniline, for example, does not mix with water and at ordinary temperatures is very little denser than water. If then we allow a drop of aniline to form slowly at the end of a glass tube immersed vertically in water, the effect of gravity is very much diminished and the final stages may be studied with comparative ease. It will be seen that the waist develops into a long thin neck which is pinched off at two places to form a small spherical drop—the so-called Plateau's spherule—which follows the larger parent drop in its descent through the surrounding water.

The Phenomenon in Slow Motion

Pitch is a queer substance, and well illustrates the difficulties with which one is faced when essaying a rigid classification. To forces of short duration pitch behaves as a solid; it is, for example, possible to cast a bell of pitch which will give a definite note when struck; but if we stand the bell on a horizontal table we find that it is no more capable of permanent existence than is a bell made of water. It will flow and spread over the table, though at a very slow rate. Similarly, if we place a block of pitch in a large dish (to prevent lateral flow) and place some corks underneath the pitch and some disks of lead on its surface, we shall find in the course of weeks or months that the lead will sink through the pitch and the corks rise to its surface. Pitch, in short, behaves to forces of long duration as a highly viscous fluid.

Suppose, then, that we take a large glass funnel and supporting the funnel on a stand, we place in it a piece of pitch. The pitch will, in course of time, flow down the funnel and form a pendent drop at the end of the funnel. The various stages in the formation and detachment of the drop can obviously be studied very much at one's leisure.

Yet another way in which the process may be followed: take a large circular frame some twenty inches in diameter—a gravel sieve will serve—and stretch across it, tambourine fashion, but not too tightly, a sheet of indiarubber.

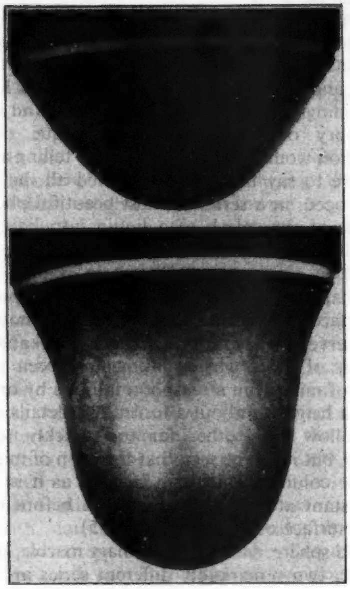


FIG. 3

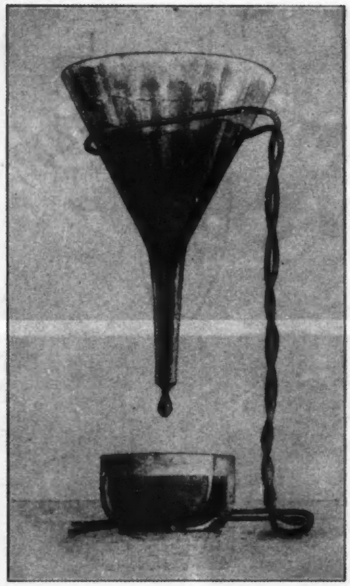


FIG. 4

keeping the sheet in place with a serving of cord and a tourniquet. If the frame is hung from a strong bracket and water is poured into it, the rubber stretches and assumes a lenticular shape, which becomes more pronounced as more water is poured in. At a certain stage, when the frame contains several gallons of water, the gigantic rubber drop swings over to a new position of equilibrium where the drop shows a well-marked waist. (Fig. 3). This position, impossible as an equilibrium position in a water drop, is possible in a drop limited by a rubber membrane, because the tension therein increases as the surface increases, whereas the tension in a liquid drop is independent of the area of the surface, provided that the temperature does not change.

High-Speed Camera Studies

But there is another and vastly more efficient way in which we can slow down the apparent speed of the process of the detachment of the drop—by taking advantage of the modern improvements in high-speed camera technique. As far back as 1886, photographic technique was such that it was possible to take a photograph of an ink-drop in the "waist" stage. This is illustrated in Fig. 4, which is reproduced from an account of a lecture on "Capillarity" given by Lord Kelvin in that year. Nowadays we do it rather differently and more easily. A compact and easily operated camera has been designed, which will take photographs at a normal rate of a thousand frames a second—a rate which, by overvolting the motor, can be increased to nearly two thousand frames a second. At a speed such as this—a fifty-foot film is taken through the camera in a second, which corresponds to a speed of about thirty miles an hour—the usual intermittent jerking of the film past the lens of the camera is quite impossible, and the film moves continuously past the lens. Between the lens and the vertically descending film a rectangular block of glass is interposed, which revolves about a horizontal axis at a maximum speed of eighty thousand revolutions per minute, and this rectangular prism, twice in each revolution, permits the passage of light from the lens to the film. During the very brief period of the exposure—about one five-thousandth part of a second—the image formed on the film is stationary with respect to the film and the photograph is recorded. There is no special difficulty in the matter of illumination—in the experiments to be described a one-thousand watt lamp and a simple projector were used.

If, then, such a film be taken at a speed of two thousand frames a second, and the film after development be run through a cinema projector at a speed of twenty frames a second, we have altered our time scale in the ratio of a hundred to one, and the history of an event which, from first to last, takes about a second in its progress, will be unfolded in the world of film in a period of, say, a minute and three-quarters, and the details of the event may easily be followed.

The splash of a drop of liquid falling into liquid, or of a solid sphere falling into a liquid, affords an example of most complex and beautiful events, the main features of which may be elucidated by an appeal to the existence of surface tension.

The story of the study and explanation of these happenings begins with some casual observations on the impact of a drop of water on a smoked glass plate made by a Rugby schoolboy some seventy years ago. The experiment is easily tried—all the requisites are a small sheet of glass smoked in a candle flame and an old-fashioned fountain-pen filler containing a little water. Drops of water are squeezed from the filler and allowed to

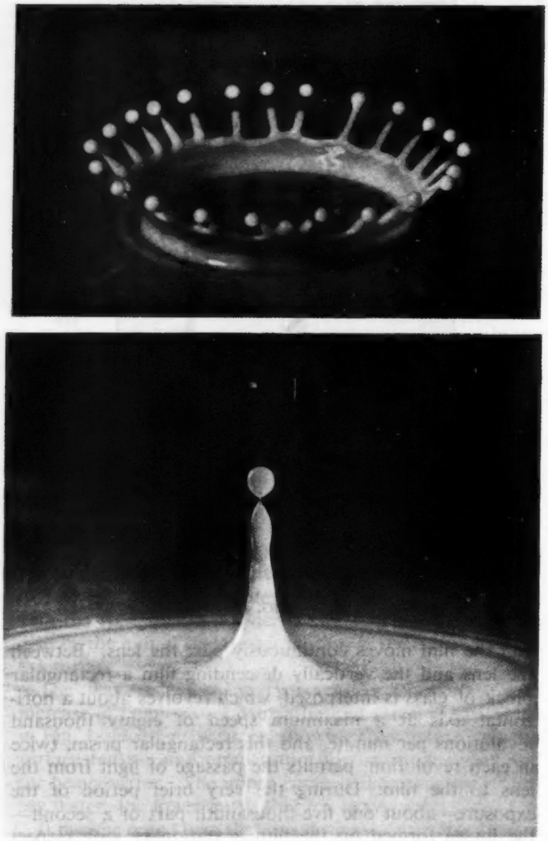


FIG. 5.—Two photographs of a splash of milk; taken by Professor Harold E. Edgerton of the Massachusetts Institute of Technology.

fall from different heights on to the smoked-glass plate. The resulting patterns are most remarkable. How would one expect the drop to behave? An obvious answer is that it might behave like an elastic ball, flattening itself slightly and coming to rest after a few oscillations about its figure of equilibrium. But the pattern on the plate tells a very different story, for the plate shows a star-fish-like pattern surrounding the central drop, as if the drop had thrown out—as indeed it had done—tentacles which had in their progress swept the glass clear of the smoke. This curious phenomenon attracted the notice of the late Professor A. M. Worthington, then a science master at Rugby, and some years later he embarked on a series of studies of splashes which are now rightly looked on as classic. Consider the difficulties which had to be surmounted with the aid of the photographic technique available in the eighteen eighties and nineties. In studying, for example, the splash made by a drop of water falling into water, a drop of water had to be set free to fall at a definite instant, and at the precise instant of its impact on the surface of water contained in a dish, the drop had to be brilliantly illuminated for a *very* short period (about a millionth of a second in Worthington's experiments) and so photographed. A second drop was then allowed to fall through precisely the same distance, but the illuminating spark was delayed for a small fraction of a second, and a second photograph taken which showed a correspondingly later stage of the splash. And so on.

The story of the ingenious technique devised by Worthington would take too long in the telling and it must suffice here to say that he surmounted all the difficulties and developed, in a series of most beautiful photographs, the details of the splash of a liquid into liquid, a solid sphere falling into a liquid, and a liquid drop impacting on a solid.

What happens when a drop of water impinges on a water surface? A simple experiment will show that the drop preserves its identity in a very remarkable manner. Take a cup of tea to which milk has not been added, and let drops of milk from a teaspoon fall one by one into the tea from a height of about a foot. The details of the first impact follow each other far too quickly to be seen separately, but it can be seen that the drop of milk emerges as a white column, which can be seen as it is stationary for an instant at its maximum height before it subsides upon the surface of the liquid. (Fig. 5).

If a solid sphere, such as an ordinary marble, be dropped into water, two remarkably different series are observed. If the sphere be rough or dusty, it drags down with it into the liquid a column of air, while the usual crater is formed on the surface of the water. But now ascending from the surface we see a tall jet of liquid thrown violently up, a jet which breaks up into a series of detached drops, as does any long slender column of liquid under the influence of surface tension forces. If the fall be higher, the crater tends to become a bubble, but the later story is the same in each instance. In both series the splash is noisy owing to the bursting of the air-bubbles into which the column of air dragged down by the descending sphere breaks up. Professor Worthington has named this the rough or basket splash from the beautiful regular basket shape of the crater.

But now try the experiment of polishing the sphere with a dry duster and dropping it into water from the same height as before. What happens is surprisingly different. The sphere slips into the water with almost magical quietness, no sound of escaping air-bubbles is heard, and no tall jet is projected violently upwards. In fact, Worthington's photographs show that when the sphere is highly polished the water, instead of forming a crater or basket is guided by the forces of cohesion closely round the surface of the sphere. No air is dragged down by the sphere in its descent and the resulting jet is quite insignificant in character. The broad differences between the two types of splash may easily be studied experimentally by anyone. The main requisites are a handful of marbles and a tall jar or jug full of water.

It would be easy to extend the story to include an account of the splash of a liquid drop on a solid surface, or the fascinating tale of the happenings *beneath* the surface when a rough solid sphere is dropped into a liquid; but this account is already long enough, and it will have amply served its purpose if it shows to the reader something of the beauty underlying very commonplace and everyday phenomena. And it may help him, too, to realise that the pursuit of science for its own sake, and without any regard to its economic effects, is very well worth while.

Dental Decay

A. J. CLEMENT, L.D.S., R.C.S., D.D.S.

THERE is an old French proverb which says "Le mort entre par la bouche"—"Death enters through the mouth." Yet even in these enlightened times the majority of people still tend to underestimate the importance of diseases of the mouth and overlook the fact that dental caries or decay is a definite disease and not a mere phenomenon. It is, in point of fact, the commonest human ailment, and recent statistics show that between 95 and 100 per cent of civilised individuals are affected by it.

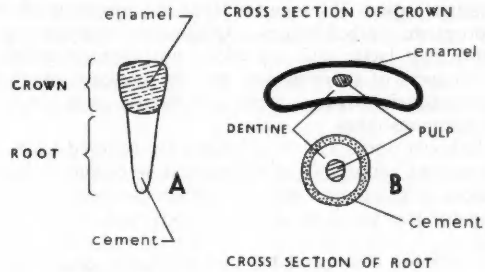
There is also a tremendous amount of ignorance as to the exact nature of dental decay. The layman believes that in some vague kind of way dental decay is bound up with dietary factors, and also cherishes the fond belief that if he regularly brushes his teeth after every meal they will never become decayed.

The human tooth (see diagram), regardless of its position in the mouth, consists of a soft central pulp of blood vessel surrounded by a hard sheath of dentine. The dentine of the tooth root is surrounded by cement, that of the crown by the enamel.

The enamel, the hardest substance in the body, is built up of a series of minute rods which pass from the outer surface of the dentine to the outer surface of the enamel in undulating, radiating lines. The dentine, which contains the same bone salts as enamel—though with a larger proportion of organic matter—consists of a matrix or background of clear material traversed by small tubules. Lying within the dentinal tubules are small fibrils which are generally reckoned to be processes or continuations of the odontoblasts—a layer of large bone-building cells situated towards the outer aspect of the pulp. In addition to the odontoblasts, the pulp contains nerves, blood vessels and various other cell types whose exact nature is of no concern in this article. Since the vascular or blood-containing pulp lies in a bony channel, any pathological disturbances, such as infection, which can cause dilatation of the blood vessels, will bring about pain through the pressure on the nerves. This is what commonly happens when toothache is experienced.

In describing normal tooth decay, there is no need to deal with the structure of the cement. All that need be said on the subject is that the structure and composition of cement is very similar to that of bone.

Microscopic examination of decayed teeth shows the various pathological stages of the disease. A "plaque" (or plate) of bacteria and acid material is first formed on the surface of the enamel. Subsequently this bacterial plaque produces an opacity of the enamel, which gradually passes along the spaces between the columns of enamel rods. The enamel then becomes soft and cheesy as the rods eventually break down and are washed away in the mouth. The space left by their disintegration forms a definite cavity. The dentine is, in turn, invaded by bacteria and various acid products which cause the solution and destruction of the dentinal tubules and matrix. At this stage the dentine substance becomes cartilaginous. Ultimately the decay reaches the pulp, the pulp invariably becoming infected by the process. Nearly all teeth make some show of putting up what may best be termed a structural resistance to the progress of the disease, but unless the actual infection is removed, it is unlikely that the progress of the disease will be permanently halted.



Diagrams showing the distribution of tissues in a tooth. (A) a typical tooth in surface view. (B) cross sections through crown and root.

The subject of the pathology of dental decay must not be left without mention being made of the various types of bacteria involved. Sir Kenneth Goadby isolated eighteen types of bacteria from decay cavities and divided them into two main groups—acid-forming bacteria which are capable of producing acids by the fermentation of carbohydrates, and the liquefying bacteria which digests the dentine after it has been acted upon by the acids. Of late much prominence has been given to an organism called the lactobacillus and although a direct causative relationship has not been established, it is certainly possible to culture the lactobacillus in practically every case of tooth decay.

Although several different theories have been put forward in an endeavour to explain the cause of dental decay, the "Chemico-Parasitic Theory" first put forward by W. D. Miller, a German scientist, who worked alongside the famous Dr. Robert Koch in the latter's bacteriological laboratory, holds sway. Dr. Miller found micro-organisms in the dentinal tubules, and showed that mouth organisms produced lactic acid from the fermentation of many types of carbohydrates. He also showed that lactic acid decalcifies (that is, dissolves away the lime salts from) enamel. Even to-day it is generally accepted that dental decay consists of two essential phases:

(*a*) The formation of various organic acids in the mouth. (These acids, among which lactic acid is prominent, can attack and destroy the surface layer of the enamel.)

(*b*) The invasion and destruction of the acid-affected tooth by various types of oral bacteria, not necessarily the same types of bacteria as those responsible for the first phase of acid formation.

It is now possible to view dental caries much more comprehensively than was possible at the time of Miller's publication, but even to-day most research workers in this

field base their fundamental picture on his theory of conjoint acid-bacterial action.

The mechanism of acid production in the mouth is complex, but a bare outline will suffice to show its nature. Acids arise in the mouth by virtue of a series of chemical reactions on certain carbohydrates, each reaction being sponsored by a system of enzymes or reaction promoters. The enzymes are associated within the bacterial flora of the mouth, but very little is known about their exact nature. The production of acids from carbohydrates is a very rapid reaction, and it is possible to demonstrate their presence within 2–3 minutes from the ingestion of the appropriate carbohydrates. Qualitative analyses have shown that lactic acid is predominant amongst the acid by-products of fermentation, but the presence of phosphero-glyceric, pyruvic, acetic and butyric acids has also been demonstrated.

Although these acid by-products are believed to be of paramount importance in the production of dental decay, it must be pointed out that the human diet often contains a certain number of natural acid foods—e.g. various fruit juices.

It is more than probable that no dental decay would arise if the accumulation of carbohydrate food material in the mouth could be prevented. The self-cleansing property of the mouth, however, depends upon two fundamental precepts, neither of which are adequately fulfilled as regards the modern diet. One is that the diet must be tough and fibrous, the other—a natural sequel to the first—is that the diet must be such that it encourages good muscular activity. Prolonged muscular action (which can be produced rather artificially with the aid of chewing-gum) promotes a good flow and movement of saliva, and is one of the best natural methods of cleansing the mouth. It is not at all in evidence with the soft, highly refined foods which form the basis of the modern diet; this is unfortunate as these foods tend to be sticky.

In the absence of any oral self-cleansing, small particles of food debris accumulate after every meal in (1) the fissures situated in tooth surfaces, (2) around the contact points of adjacent teeth (the inter-proximal spaces), (3) in any small tooth gaps (such as are usually caused by previous tooth extractions and the subsequent drifting of the remaining teeth), (4) around any overhanging ledges that may arise around old fillings, and finally (5) at any point where the enamel is structurally deficient.

It has been pointed out that the first stage of the disease was the formation of a dental plaque or mass of bacteria and acid material on the surface of the enamel. The carbohydrate food debris accumulates in any crevice or spaces which are mechanically able to accommodate it. Here it undergoes fermentation. If the area of plaque formation is hygienically inaccessible, the bacterial mass may reside here for a considerable time and subsequent additions of carbohydrate food provide an ideal nesting place for bacteria. The sticky mucin content of the saliva (large quantities of it are found in sticky, ropy salivas) is deposited on this mass and makes the plaque adhere strongly to the enamel surface. (As an example of one of nature's innumerable "laws of cussedness", it may be pointed out that the separation and deposition of mucin from saliva is greatly accelerated by the presence of weak acids such as are found in the areas of fermentation.) The acids in these plaques are sufficiently powerful to decalcify the enamel and provide a means of entry for the bacteria into the tooth substance.

The exact role which the saliva plays in the decay process is still highly debatable. At one time it was believed that a direct relationship existed between the degree of acidity of the saliva and the incidence of decay. Normal specimens of saliva fluctuate around the point of neutrality, but it is not uncommon to find specimens of which the reaction is outside the normal range and quite definitely acid or alkali. Sticky, mucinous salivas often seem to be more acid than thin, watery salivas. It seems unlikely, however, that the saliva, *per se*, is ever sufficiently acid to cause decalcification of the enamel.

Saliva is a complex secretion and contains several inorganic and organic compounds. Prominent amongst the several inorganic salts is calcium phosphate which belongs to the group of chemical salts known as "buffers". Buffer salts possess the power of combining with either acids or alkali and rendering them neutral in reaction. By virtue of its buffer salts the saliva possesses to a small degree the power of neutralising any weak acids with which it may come in contact. In stagnant areas it is obvious that the saliva can neither wash away food debris nor gain access to the acids being formed underneath the impacted food debris and bacterial plaques. In these circumstances the beneficial action of saliva is much reduced.

A Paradox

Although the foregoing facts might seem to offer a complete explanation for the whole process of decay, there are still several aspects for which the explanation has yet to be found. Individual susceptibility is one of them. Some individuals take great pains to maintain a high degree of oral hygiene, brushing their teeth after every meal and eating a normal diet. And yet their teeth decay rapidly. Other individuals, subsisting on approximately the same diet, may have never brushed their teeth at all and yet show no signs of decay.

Another interesting phenomenon of dental decay is its great prevalence during childhood and adolescence. In early life decay seems more prominent and the whole process more rapid and acute than when it occurs in later years.

As man reaches the close of his second decade some of the teeth (in particular, the lower incisors) frequently show signs of becoming encrusted with a deposit of tartar. Tartar formation is a process somewhat analogous to the furring of a kettle, the tartar consisting of a mixture of calcium phosphate and calcium carbonate bound together in a hard mass by organic matter. It is generally reckoned to be an alkaline process and although tartar formation and dental decay are frequently present in the mouth at the same time, it is a curious fact that as tartar formation supervenes the incidence of dental decay often becomes very much less.

Several schools of research workers believe that dental decay arises in teeth which are structurally deficient in some way. Dental decay does definitely seem to progress more rapidly along lines of structural weakness, and has, as previously mentioned, been shown to be more prone to commence in areas of poor enamel calcification. Lady

Mellanby has shown that the teeth of dogs which have been reared on a diet deficient in Vitamin D are structurally altered and decay far more readily. Certain individuals who have grown up in districts where the soil or water has a high fluorine content possess badly mottled or discoloured teeth, but these teeth are much more resistant to dental decay than is normally the case.

Taking all in all, it does not seem possible to offer any complete explanation for the cause of dental decay on constitutional and structural grounds. The evidence does seem to show, however, that these same factors possess a powerful predisposing influence on the incidence of the disease.

The effect of Modern Diet

Although it is possible to find examples of dental decay in the skulls of all races from the very dawn of history down to the present day, it is only since man began to consume soft, pappy carbohydrate foods (e.g. sugar and starch foods) that the ravages have really become universally widespread.

The decay encountered in most of the older types of skulls is rather different from that which we know to-day. It is a decay of attrition in which the enamel structure has first been worn away by the mastication of solid, gritty foods before decay proper commenced in the dentine. The Egyptian dynasties provide interesting evidence of the influence of diet upon dental health. During the early dynasties the Egyptians subsisted on a primitive type of diet and possessed teeth which were comparatively free from decay; later they took to using sugar, and with its widespread use dental decay became prevalent in Egyptian civilisation. The late J. R. Mummery, an English research worker of international repute in the last century, collected a wealth of facts and figures about the relationship between diet and decay amongst existing human races. His statistics show conclusively the important role played by the diet. Primitive races subsisting on primitive diets were found to be relatively free from dental decay. Other primitive races which had come to embrace the refined and unnatural civilised diet invariably showed its presence. Even to-day it is still possible to find relatively immune peoples such as the Eskimos or, to take an example nearer home, the inhabitants of the Outer Hebrides. The Eskimos live almost exclusively on fatty animal foods and seem to be decay-immune as long as they remain outside the pale of civilisation. Directly they come in contract with the soft diet of civilised mankind they seem to lose their immunity. As regards the second example quoted, many of the Hebrideans, even to this day, live largely upon a diet of sea foods, oats and barley. They take practically no refined carbohydrate food.

The Great War provided further evidence along these lines. In Great Britain, sugar was very scarce during the war years. It was generally agreed among dentists in practice at that time that the dental health of school children during and immediately after the war was at a far higher level than during the immediate pre-war period.

Several species of animals exhibit a susceptibility to dental caries, although it is never found in the same degree of prevalence as in man. In the wild state apes and monkeys alone show the disease, while in captive animals the disease occurs in apes, monkeys, bears, kangaroos and rodents. The higher frequency among captive animals is believed to be due to the altered diet.

Carbohydrates, the chief source of the decalcifying acids, include cellulose, starches, and sugars. Cellulose, the chief constituent of vegetable fibre, passes through the mouth unchanged by virtue of its intact cellulose envelope. Uncooked starch is similarly unaffected, but when cooked the ptyalin enzyme of the saliva can readily change it into the sugar maltose which, in turn, is converted into acid material in a series of chemical changes.

Starch is less dangerous from the dental view-point than the sugars as acid formation from it is slower. It is of interest that the synthetic product known as saccharin does not undergo fermentation in the mouth.

If carbohydrates are so interwoven with the cause of dental decay, it might appear at first sight that the simplest solution would be to abstain from all carbohydrate foods. Apart from their great value as energy-producing foods, however, carbohydrates are so highly esteemed that most individuals would rather suffer the occasional pain and inconvenience of tooth decay than eliminate them from their diet.

Two different tests have been devised for demonstrating dental caries activity in any mouth, so that it is now possible to try out the immediate effect of any procedure without waiting a long time for the evidence of the results. The bacteriological test developed by Bunting and Jay of Michigan depends on the fact that, when active decay is present, the lactobacillus organism is also present. When it is consistently absent the process is inactive. The test merely involves bacteriological estimations, and has been shown to agree with clinical observations in about 85 per cent of cases.

The chemical test was first demonstrated by Fosdick of Chicago. It is based upon the rate of acid formation in a glucose saliva-powdered enamel mixture. The saliva is collected from the patient undergoing examination, and mixed with fixed quantities of glucose and specially prepared, finely ground tooth enamel. It is then incubated for four hours, and the amount of acid formed is estimated by the quantitative analysis of the calcium that has been dissolved from the enamel. This test is of approximately the same degree of accuracy, namely 85 per cent, when compared with clinical observations.

Controlling Decay

The possible methods of approaching the problem of the control of dental caries can be classified into four groups as follows:

(*a*) The elimination of acids and all acid-forming foods from the diet (i.e. dietary control).

(*b*) The elimination of any factors in the mouth which tend to lead to food stagnation and plaque formation. This is essentially a mechanical approach.

(*c*) The destruction or poisoning of the appropriate bacterial-enzyme systems of the mouth (i.e. antiseptic control).

(*d*) The general immunisation of the patient or the local increasing of the self-protective property of the mouth and teeth.

All of these methods of approach have been investigated

at one time or another. Some of them in the laboratory and some by experiments on carefully controlled groups of individuals in schools and institutions. It will be best to discuss each method individually.

The elimination of carbohydrates from the diet has proved completely impracticable for universal adoption. As previously stated the majority of individuals would rather lose a few teeth than forgo what is virtually one of the tastiest portions of their diet. Long-term experiments carried out in institutions have shown, however, the value of a rigid control of the carbohydrate intake. If the lay public were better informed as to the relative merits and demerits of the carbohydrate food groups, they might gradually be taught to adopt a more suitable carbohydrate dietary programme. It may yet prove possible to "doctor" or buffer the dangerous carbohydrate foods, thus rendering them harmless to the oral bacteria. This is an exceedingly difficult approach, however—particularly when one remembers that any such process must not interfere with the natural digestion of carbohydrates.

The Mechanical Approach

The removal of all mechanical factors involved in plaque formation is also very difficult, as it is most questionable whether the man will ever revert to the tough fibrous foods which promote vigorous muscular action and a high degree of self-cleansing. Such factors as irregularities of the tooth position and tooth structure can, of course, be remedied by adequate dental treatment and periodic overhaul. Some dentists, working along these lines, have advocated and practised the excision of the fissures from the masticating surface of the teeth, thereby removing some of the potentially most dangerous tooth areas before thay have a chance to decay.

From the point of view of good mouth cleansing, the toothbrush is not by any means as efficient a method as could be desired. The act of brushing the teeth is a laborious one, and unless carried out regularly after every meal is not of much use in caries prevention. Another point of interest about the toothbrush is the fact that very few people are educated in its correct use. Most individuals brush their teeth transversely—in a horizontal direction—and thereby tend to wedge a number of the smaller particles of food more tightly into the gaps and spaces in between the teeth. The "Charters Technique" of brushing the teeth, developed in America and widely propagandised there, illustrates the only possible way in which the food can be eliminated from these dangerous spaces. The brush is placed on the teeth at right angles to the long axis. The bristles are then gently forced between the teeth, care being taken not to pierce the gums by keeping the bristles away from the gum area. Pressure is then exerted with slight rotary or vibratory motion. For this method to be really effective, the process must be repeated several times in each area of the mouth. Human nature being what it is, it is very questionable whether any individual would ever be persuaded to religiously practise the Charter's Brushing Technique after every meal.

Much the same considerations apply to the use of the tooth-pick and dental floss silk (silk thread which is drawn through the spaces in between the teeth). Both are useful in removing food debris from inaccessible areas, but unless they are regularly used cannot be reckoned to be entirely satisfactory. They have the added disadvantage that gum injury can readily be incurred. Social reasons must also inevitably prevent their widespread adoption.

The mouth wash or mouth rinse is one of the most efficient mechanical methods of cleansing the mouth free of food debris. One of America's most famous dental research scientists is of the opinion that, in the light of present knowledge, the most useful method of keeping decay down to its minimum incidence is the rinsing of the mouth with plain water after every meal.

One other method of mechanically cleansing the mouth remains for consideration, namely, the use of chewing-gum. This method, although widely practised by the Americans, has never been very popular in England. The presence of many Americans over here during the war may serve to change this attitude. Chewing-gum is a particularly useful cleansing agent; it is adhesive and food particles are readily "mopped up". There is, however, one obvious disadvantage of chewing-gum in its present form—namely, the presence of a small amount of fermentable carbohydrate in the sugar coating. This could be quite easily overcome, however, by the substitution of saccharin for the sugar. It is quite possible that chewing-gum may yet come to play a considerably larger part in the maintenance of oral hygiene than hitherto.

The method of controlling caries by poisoning the oral bacterial-enzyme system, is receiving considerable attention at the present time. Although most of the work to date is still in the laboratory stage, it holds out promise of a fair measure of success. A poisonous drug is either applied directly to the teeth or is incorporated into a mouth wash or rinse, or even into the diet itself. Hexyl resorcinol, metaphen, quinine, urea, zephiran, iodoacetic acid and sodium fluoride have all been tried out in mouth washes. B. F. Miller has noticeably reduced the caries incidence in rats by incorporating small amounts of sodium fluoride or iodoacetate into a caries-producing diet. Sodium fluoride, however, is a very toxic substance, and as yet sufficient data are not available to warrant its inclusion in the human diet. L. S. Fosdick has recently mentioned the local use of vitamin K_4 to inhibit the production of acid from carbohydrates. He incorporates the vitamin in a chewing-gum basis.

For some years, one of the commonest methods of inhibiting caries in newly erupted teeth has been the deposition of silver in potential decay areas of easy access. Ammoniacal silver nitrate is applied directly to the tooth and then chemically reduced to silver by one of several suitable reducing agents. The metallic silver deposit produces a black stain, however, and its use is therefore only justifiable in the case of the posterior or back teeth.

Experiments with Fluorine

The relationship that exists between the chemical element fluorine and dental caries has lately been resurrected to receive much publicity in the Press. It has been known for many years that individuals reared in certain areas in which the soil contained more fluorine than normal, were very liable to possess mottled or badly discoloured teeth. Examples of such areas are the Rocky Mountains in North America and parts of Essex and the

Peak district of Derbyshire in England. These mottled teeth seem to be far more immune to decay than the normal tooth, provided the mottling is of not too severe a degree, and outstanding statistics recently produced in Texas have rekindled interest in the striking relationship that obviously exists between fluorine and caries immunity. The role played by fluorine is still obscure but at the moment the most likely hypothesis supports the view that fluorine acts in its capacity as a caries immuniser in two ways; firstly, by entering into some kind of chemical combination with the enamel and dentine, and secondly by virtue of being an enzyme poison. From the indisputable observation that a local application of fluorine paste (made by mixing sodium fluoride with glycerine) will "desensitise" sensitive tooth areas (in particular those that occur round the gum margin of the teeth) we are provided with further evidence that fluorine has a direct action on the tooth substance.

The experiments in which the general, physiological action of fluorine upon the teeth is being investigated are long-term investigations and will require several years for their completion. However, the authorities are sufficiently interested, particularly in America, to have permitted the addition of fluorine to the water supply of several communities. This means that children growing up in the localities where such fluorinated water is on tap will be receiving a continuous supply of water to which has been added a small calculated amount of fluorine. (It should be noted that, in all but minute quantities, fluorine is a very toxic substance). The dental health picture of these children will, in ten years time say, then be compared with that of a similar group of children brought up on non-fluorinated water.

Geologists, too, are collecting knowledge which is likely to be of interest in this connection and there is now a great deal of survey work going on with the object of mapping out those areas in which the soil contains a large proportion of fluorine; in these areas the crops are likely to contain more of this valuable element.

By the local administration of fluorine it is possible to use fluorides in far greater concentrations than is possible with the method outlined above. To date sodium fluoride mouthwashes and sodium fluoride paste have been tried out in this capacity. The difficulty lies in the transitory effect of the application and scientists are still trying to achieve a technique whereby local application of the fluorine will have a permanent physiological effect upon the tooth. In fluorine we obviously have an element of great value in the prevention of dental decay. For the moment we must, however, continue to look upon it as a preventative and not as the missing link to the extraordinary complex picture presented by dental decay.

The Army Education Scheme

THE aims and objects of the large-scale experiment in adult education now in train in the army are described in a document entitled *The Army Education Scheme: the plan for the release period* (Stationery Office, 2*d*.). Scientific subjects would appear to be receiving due attention, courses being provided in General Science, Physics, Chemistry, Biology, Elementary Anatomy and Physiology, Nutrition, and Psychology, for instance. In view of the importance of this scheme, we feel sure that readers will be interested in the following note about A.E.S. from an army sergeant who has first-hand knowledge from both the "transmitting" and "receiving" ends of the precursors to A.E.S.

The Army Education Scheme, writes our correspondent, is an ambitious attempt to give soldiers adult education, with the aim not only of providing them with some instruction in the career they may select when they are demobilised, but also of introducing them to the social and political conditions to which they will return. Every man and woman, at home and abroad, will receive six hours education each week, in the Army's time, and will be free to choose his or her own subject. Out of these six hours, two hours each week will be given to current affairs, irrespective of the special subject selected.

The emphasis is not upon vocational training, which, it is felt, is already covered by the Ministry of Labour schemes. Nevertheless, an attempt will be made to give a general introduction to any trade or profession which a soldier may wish to take up upon release from the army. The technical subjects include, for example, engineering, radio and telephony, elementary surveying, and building construction. Those who have jobs to go back to are amply provided for under the new scheme by the hobbies and purely cultural interests which are included in it. More important, however, is the attempt to give general education in citizenship, and to fit men and women into society again who have for so long been divorced from it.

Anyone who has had experience of the army, or for that matter of any body isolated from the general community will realise the urgent need for such a scheme. It is not only that the general standard of education is deplorably low. (This perhaps is to be expected after the partial disorganisation of education by six years of war, although it is a shock to find youths of eighteen incapable of spelling simple words or of solving elementary problems in arithmetic.) But it is the cynicism founded upon ignorance—and experience, the distrust of all politics, the contempt for government as such, which must be combated if the soldiers are to go back and play an active and constructive part in civil life.

At once one meets the first obstacle to the scheme—the indifference with which it is received by those who could benefit most from it. Some are openly indifferent; they resent the implication that they have anything to learn. Others are apathetic; they regard it as another stunt on the army's part and wait passively until the moment when they will be released. A minority is interested.

This obstacle can be overcome by a convincing presentation of the scheme to the army, and the laying of the bogy word—education. But the successful accomplishment of the scheme is confronted with greater difficulties. It may be possible to obtain the necessary books and equipment, but how will it be possible to find the requisite number of instructors? Under the six main headings are grouped 109 subjects, some divided into three grades of proficiency. Each unit is to provide its own instructors in each subject from its existing personnel, assisted to a very limited extent by civilian lecturers, and with provision for a certain interchange of instructors among units. This system of taking in each other's washing is not satisfactory, although perhaps unavoidable, owing to the great numbers which the scheme is to cover. In addition, the personnel will be constantly changing, as the various groups are released, and many potential instructors who have spent some years in the army will find that their knowledge of the subject which they wish to teach is out of date.

To meet this difficulty the army authorities have instituted Formation Colleges in each Command which will provide refresher courses for instructors and will supply advanced courses for students who are capable of benefiting from them.

However, the scheme is to go forward. The Army Education Corps will be responsible for general supervision and, strange as it may appear to those who look upon the army as traditionally hidebound, the A.E.C. has an excellent reputation for the educational work which it has already accomplished. Certainly this is one of the greatest opportunities that the country has ever had for ensuring that a great proportion of its citizens receive adult education at a time when it is most urgently needed.

THE programme "Your Questions Answered", which reached its 100th edition last month, is appreciated by many besides the members of the Forces serving overseas for whose particular benefit the programme was designed. The science items it includes are singularly effective and represent one of the most successful efforts of the B.B.C. in the field of scientific exposition. In this article the producer of "Your Questions Answered" describes the purpose behind the programme and the way a technique of presentation has been evolved to meet the demand for straight answers to straight questions on scientific subjects and others.

"Your Questions Answered"

TERRY GOMPERTZ

ALTHOUGH "Your Questions Answered" has just reached its century, the hundredth programme (which went on the air on Friday, July 13th) was in some ways different in form from edition number one. This, of course, is typical of what often happens with a long series. Director and producer will work out a plan at the beginning, having a fairly clear idea of the job they are trying to do, but as the series progresses the audience starts to play its part in giving criticism and suggestions, and often in the light of these a programme may alter or enlarge its scope. New ideas and techniques will be tried out until, by a kind of dialectical process, the right mixture has been achieved. With such programmes as "Your Questions Answered", in which direct co-operation of the audience is requested, this process is very marked indeed. In this particular case the questions acted as the major factor in influencing the shape of the programme. And it was as a result of a big demand for information in two particular fields that the shape of Edition 100 differed from Edition No. 1. One of these fields was music; the other, with which this article is concerned, was science.

Right from the start queries on scientific subjects started to come in. The second programme carried an answer about the vitamin content of tinned food—obviously of intense interest to the group who had sent their airgraph from a desert camp in the Middle East. The origin of yeast came next—from a man who had been struck by the unleavened bread in the East. A random selection from the programme contents in the last few months shows subjects such as alternative fuels to petrol, possibilities of atomic power, sulphonamide drugs, cosmic rays, plastics, causes of weather conditions in the Middle East, change of blood temperature, the age of the earth, and outcrop coal. It was obvious that this audience of serving men, many of them seeing other parts of the world for the first time, and living under new conditions, had plenty to ask as a result of their fresh experience. It was interesting to see which kinds of questions came from the various branches of the three services, and from which kind of environment. As might be expected, the great majority of the most interesting questions came from men with some technical knowledge—R.A.F. ground crews, tank crews, signalmen, R.Es., gunners, and wireless and gunnery men of the Royal and Merchant Navies—all these have always been among our best correspondents. One subsidiary reason for this is undoubtedly that in the case of some of the units mentioned their listening conditions have been of the sort rendering concentrated listening possible. This, as opposed to the ordinary listening conditions—in the crowded canteen or recreation unit with a crowd around the solitary loud-speaker, ready, quite naturally, to tune elsewhere the moment a programme demands concentrated listening.

But although these servicemen found themselves in new environments which stimulated new lines of thought, they were, also, essentially the same people who, when travelling to their daily jobs in peacetime, sat in trains reading every conceivable kind of technical journal, popular works on philosophy and natural science; people who were amateur photographers, radio enthusiasts, tinkerers with every kind of mechanical apparatus, pigeon fanciers, rabbit breeders, collectors of everything under the sun, and keen nature observers; in short, people who spend their spare time becoming most knowledgeable about some subject, and who, when they happen to meet any kind of expert, are likely to say: "You're an expert in this, that or the other, aren't you. Well, I've always wondered . . ."

The Level of Approach

It was our aim when we started "Your Questions Answered" to cater for this kind of person. As well as doing this, however, we wanted to get at the wider audience who, for one reason or another, had not hitherto done very much thinking about anything. Although this article is about the science section of the programme it should be pointed out here that other sections are devoted weekly to current affairs, music, and general questions. We hoped, and not by any means in vain, that those listening from interest in one type of question would by degrees become interested in the others; that, for instance, men with political interests would start to take notice of the science section, and vice versa. As always in radio, our major problem was time. The overall timing of "Your Questions Answered" is thirty minutes; the majority vote was for a variety of subjects in each edition, and this meant answers of not more than five to six minutes. Yet, because we wished to cater for the least well educated in the audience, the expert had to be careful not to assume more than elementary knowledge on the part of those listeneing. Another important factor was the amount of information that can safely be packed into five or six minutes of speech; because the spoken word cannot, as can the printed word, be pondered over without missing the next few sentences. This last drawback, together with the fact that a broadcast can use no such aids to understanding as photographs, diagrams, etc., means more "wastage" in the broadcast script of eight hundred words than in a newspaper article of similar length. With these difficulties in mind, and the questions on scientific subjects rolling in steadily, we decided to devote at least five minutes a week to a science question; often we have carried two, and sometimes a whole programme, with the exception of the musical question, has been devoted to science.

Scripts for the 100th edition of *Your Questions Answered* are finally checked before the programme takes the air. The question master, Richard Bennett, holds his copy; the others, all well known broadcasters on this programme, are (from left to right)—Mr. J. F. Horrabin, cartographer; Dr. S. Lilley, mathematician; Mr. Anthony Barnett, biologist, and Sir Henry Bunbury, authority on political and economic affairs. (*B.B.C. photograph*).

From the start scientific workers in all fields gave us a great deal of help and, with few exceptions, the limitation of time seemed to act as a kind of spur. One of the most outstanding examples of this was when, with some misgivings, I wrote to the late Sir Arthur Eddington asking him to take part in the first of our programmes to be heard to listeners at home. An R.A.F. man serving in the Middle East had written in asking "Are there other universes than our own?" and referred to one of Eddington's popular works. Would he, I asked, be willing to cope with the question in six or seven minutes. He replied he was willing to try—the result was a most lucid explanation given in the form of a dialogue between him and the question master—an explanation that led to a great many more questions coming in.

This dialogue form I have mentioned was the technique we used from the beginning for all questions. But it is an interesting point that it was in the science answers it most proved its worth. So much so that we have has a number of letters beginning: "Please answer this in *Questions Answered* style." The chief advantage of the dialogue for putting over scientific information was very well described by David Evans (a frequent contributor to the programme) in an earlier number of "Discovery". Writing of the necessity of such tricks as repetition, parallel restatement and vivid examples in a broadcast on scientific subjects, Evans summed up the case for using a dialogue in this way:

"There is, however, one form of exposition in which direct repetition is possible while retaining a naturalness of delivery. This is the dialogue form in which the unseen audience has one representative as a compere or interlocutor. The argument then proceeds smoothly, the compere acting the part of the stooge, or being struck (it is to be hoped with some show of realism) by suitable bright ideas at the correct moments. Then there comes a point where some crucial fact, perhaps a little difficult to grasp, must be stated. The dialogue form then enables the speaker to make his statement, the compere to take the difficult point up and repeat it in the same words and to ask for further explanation. The speaker then restates his point and proceeds to explanation. In this way, any particular salient fact of which special notice must be taken if the listener is to follow the rest of the argument can be stated no less than three times. . . . The continual interchange and alteration of voices keeps the attention at the rather high level necessary for the absorption of scientific material, and the speeches of the compere also serve the function of giving the audience time to think —in the ideal case, time to think along the same lines as the compere."

Concrete Example

It will be obvious from the above that the programme has to be carefully scripted though the actual broadcast has to sound as spontaneous as possible. I have found that

after one or two experiences, and often from the start, most scientists accustomed to explaining their subject turn in a very good working script. As I myself represent the complete layman, if the explanation satisfies me I usually feel happy about it being understandable by an audience. If not, then we go on hammering at various points until some concrete image suggests itself which seems to me and the expert to do the trick. Any number of times I have taken people into the street and said: "Now let's look around and see what there is in an ordinary familiar scene like this that can get your point over." I think it was an occasion like this which promoted this exchange in an explanation by Evans about the speed of light—he was explaining how a beam of light bends as it enters glass:

COMPERE: But how is it that the beam is bent as it enters the glass?

EVANS: Well, suppose you have a series of light waves running obliquely in towards a piece of glass. If they don't strike square on to the glass, one end of each wave will arrive before the other. Think of a body of troops marching along, ten abreast. They are supposed to represent the light waves. They march along a road at four miles an hour and come to a strip of mud running diagonally across the road, in which a man can only march at two miles an hour.

COMPERE: Now, wait a bit, let's see if I've got this clear. If that strip of mud ran straight across the road at right angles the effect would be that the whole front of the column would be slowed down simultaneously.

EVANS: Yes, but because the edge of the mud strip runs across the road diagonally, the man on the left of the front rank gets into the mud first and is slowed up. Then the man next to him in the same rank gets bogged, and slows up. Successively, each man in the front rank will be slowed down. However, the men on the right of the front rank will still be going on at four miles an hour when the men in the mud are only going at two miles an hour, so that the whole front rank will get into a staggered formation. That is, the whole rank will be swung round, just as the light waves are when they get into a medium such as glass in which light moves slower."

Questions such as this one on the speed of light come in constantly and they—indeed, all those on the physics side—are perhaps the most difficult to deal with because so much that is abstract has somehow to be given concrete shape. But there is no doubt that there is a very big demand, particularly from men in more lonely places, for knowledge of this kind. A great many of these and other questions arise from discussion and argument among small groups of men, and satisfactory answers have often led to a regular listening group who send in a lot more questions. For some reason biological and chemistry questions were far fewer in the beginning but by a judicious insertion of "the kind of thing that's often asked" about these subjects we started to get quite a number, and now the mixture is fairly even. New experience and fresh environment definitely inspire a high proportion: for instance, some men who had just been inoculated wanted to understand the process. The answer, which was given by Dr. Parsons of Cambridge, was an interesting attempt to make the listener understand not only what happens in inoculation, but, by taking him step by step from Pasteur onwards, to follow the process by which inoculation became standard practice in medical science. In this particular instance we had the interest of getting first-hand reaction to the answer, because Parsons was lecturing to some naval men in the Orkneys at that time, so we pre-recorded his answer and he had the opportunity of seeing their reaction. It was evident that the treatment of the subject was a good "curtain raiser" to general discussion and, where there was an expert present, to more questions.

The Audience's Interests

Readers of *DISCOVERY* will probably be interested in the variety of subjects handled in "Your Questions Answered" during the last two years, and in the names of the people who have handled them. Looking through our card index I made a note of the subjects lying next to each other under the various letters. Taking "A" we find an explanation of aircraft speeds by Dr. Cosslett of the Electrical Laboratory, Oxford (who has lectured on such subjects to R.A.F. cadets during the war); an answer about the connecting links between the vegetable and animal kingdoms by Professor Haldane (who was especially asked for); a piece on "Splitting the Atom" by Dr. J. C. Daunt of the Clarendon Laboratory, Oxford.

Under "B" there is an entry on "Blood Oranges" (question from Palestine—answer by M. G. Crane of John Innes); under "C" a card headed "Caterpillars" shows Dr. Hobby, the entomologist, dealing with the Apantales (a specimen of eggs were sent in with the request for information about the caterpillar which laid these eggs and then died). Also under "C" come electrical and heat conductors dealt with by Dr. Mendelssohn. "D" gives us an entry for Desert—with a note showing how the geologist Dr. L. Hawkes explained certain things about the Sahara. Next to that comes a contribution by Sir John Boyd Orr on the subject of a minimum diet. "E" shows Professor A. V. Hill talking about the way in which the body stores and makes energy. Turning to "F" there is an explanation of the fog dispersal work done in "Fido"—given by the officer in charge of the meteorological side, Squadron-Leader Edge; the "Frequency Ranges of the Human Ear" follows on—explained by Dr. Alexander, who had the rare advantage of being able to illustrate his explanation. Under "L" comes the simple heading "What is Life", which is a reminder of the time when Anthony Barnett boiled down a half-hour conversation on this subject to a six-minute broadcast. Near this are entries on magnetism and low temperature research. "P" entries show us that the technical side of Operation Pluto was described by A. C. Hartley, the technical director in charge, and information on Proteins given by Dr. Dennis Riley. Under "R" we find Dr. Julian Huxley dealing with the important subject of racial colouring and differences between races with reference to the racial theories. Close to this card is one showing Sex-linkage in chickens explained by Paul 'Espinasse—and so on. This random sample shows, I think, the variety of subjects tackled.

In the index, too, are two aspects of science which we have covered and which are worthy of special mention. The first is the social relations of science to-day—a subject on which both Dr. Huxley and Sir Robert Watson-Watt

have spoken. The second is the historical approach to science, on which we have had the benefit of a number of contributions from Dr. Lilley.

In one instance Lilley took the range finder and discussed how and when the principles involved in its construction were evolved. In a special edition broadcast from Cambridge he described the significance of the work of Clerk Maxwell, and in the hundredth edition discussed the early work of the Royal Society. Linking science with the humanities, Professor Farrington has explained the contributions to scientific thought of the early Greek philosophers. Although there are far fewer questions along these lines, there can, I think, be no doubt as to the value of answers of this kind in showing science in its true relation to the progress of man. In conclusion: no producer would feel qualified to give an estimate of the value of the programme for which he is responsible. But he can say what he is attempting to do and whether his attempts are meeting with success (and there is evidence to show this). With regard to the science section of "Your Questions Answered", it is obvious that there is among Forces overseas and at home a demand for information on scientific subjects. I have described the attempt we have made and are making in this programme to deal with that demand. As far as success is measurable, I would say simply that the Forces ask for more along the same lines, but that no producer ever feels he is doing anything as well as it can be done. And, finally, this programme is only one among the number which attempt to stimulate people to think by means of giving them accurate information in terms which they can understand.

SOVIET SCIENCE—*continued from page* 239

suitable for display and are hence liable to neglect aspects of the site that cannot be so used but may really be of greater scientific interest. I.I.M.K. is, of course, free of such limitations. So in conjunction with the Ukrainian Institute it has sponsored Passek's five campaigns on the late neolithic village of Kolomishchina near Kiev. These resulted in hardly any novel museum pieces, but in the total excavation of a whole Stone Age settlement—an operation conducted only twice before in Europe (in Germany), but that yields unique information on the social organisation and economy of such a community. A full report on the first three campaigns has just been published by the Ukrainian Academy. Other large-scale operations recently undertaken by I.I.M.K. include an archaeological survey of the ancient Khorasmia (the Oxus valley) in conjunction with the Hermitage, the Historical Museum and local bodies, and Okladnikov's ethnographic and archaeological exploration of the Lena. At the same time the Georgian Historical Institute sponsored Kuftin's "five year plan" of excavation in the old Georgian province of Trialeti, the publication of which earned the excavator the Stalin prize in 1941. Centralised direction allows the objectives of expeditions to be selected in accordance with a long-term policy determined indeed on the one hand by the exigencies of national development (an irrigation scheme for instance may threaten with destruction a number of ancient monuments that must be first examined), but on the other by a balanced estimate of the deficiencies of archaeological knowledge. It has also ensured sufficient continuity for the completion of the projects started and eventual publication of the results.

An Ex-miner Discovered Manganese

ALTHOUGH Scheele, Sweden's poor pharmacist who became an eminent chemist, has been accorded considerable attention by biographers, his close friend Gahn remains almost unknown. Yet Gahn, born on August 19, 1745, succeeded in one direction where Scheele failed: that is, in liberating the element manganese from an eternity in bondage. Johann Gottlieb Gahn worked as a boy in conditions worse than any poor apothecary's apprentice experienced, labouring in the lowest and wettest levels of the mines of Helsingland. That opening in life determined much of his career, a career that was centred upon metals and ores, and which led him to become Assessor at the College of mines, to manage his own mines and smelters in later years and, from the Stora Kopparberg works, to supply urgent demands for copper to sheath ships during the American Revolution. (It was at the Stora Copper Works, incidentally, that De Laval, born just a century ago and now remembered for his steam-turbines and cream-separator, began his upward surge.)

Gahn must have been one of Bergman's most successful pupils, becoming analyst and mineralogist. According to Berzelius, he always carried a blowpipe in his pocket, even on the shortest of excursions. Gahn published a little on smelting but rather more on the technique of the blowpipe; his prowess with it is told of by Berzelius, who once watched him conjure metallic copper from the ash of a certain type of paper. Gahn's interest in chemistry was enlivened by his sulphuric acid plant in which Berzelius had a share, this plant being at Gripsholm where the iron pyrites from the Fahlun mines was roasted. And it was in this acid plant that Berzelius thought he had discovered tellurium but had actually found its sister element, selenium, a thread of which he sent to Wollaston. (Gahn resembled this English chemist so strikingly that he was called "the Wollaston of Stockholm".)

The discovery of manganese by Gahn is one of the highlights in the history of this metal so essential for steel-making that none is made without it. The black oxide, known to every schoolboy in his preparation of both oxygen and chlorine, was used centuries ago as "kohl"—as black as coal and as old as vanity—to emphasise the eyelashes of Egyptian beauties. It appeared in the making of ancient glass, both for "bleaching" it and in larger amounts for imparting amethyst tints. Yet "wad", "psilomene" or "pyrolusite" (as it was called through several centuries) contained an element which defied all efforts to isolate it—an element that was called "the Chameleon Metal" since it yielded purple, red and green liquors on fusion with alkalis and oxidisers. In the tale of manganese one hears much of Josiah Heath, the Indian civil servant who introduced a small proportion of manganese into steel-making, and of Robert Hadfield—"young Hadfield"—who in his father's Sheffield works sought a special steel for the wheels of tramcars that had to grind up Yorkshire hills and found 13 to be his lucky number—13 per cent. manganese—for "Manganese Steel". But let us remember 1774 as the beginning of manganese metal as we know it, as the year when Gahn, ex-miner who had no doubt tried his famous blowpipe without avail on the black pigment oxide of classical days, rolled up his sleeves and refused to be beaten. Mixing the manganese oxide with a little oil and powdered charcoal, surrounding the mixture with further charcoal, luting a second crucible over the first one to form a *creuset brasqué*, Gahn applied intense heat and was rewarded with a button of metal that was to prove in fact as magic as was Alf's Button in fiction. M. SCHOFIELD.

Cont: from page 216 of July issue]

The Fauna of Burma and Adjacent Lands

J. P. HARDING, Ph.D., F.Z.S.

The apparent absence of life in a tropical forest has often been commented upon; although there is a great variety of mammals, birds and reptiles, many of them are nocturnal and remain hidden during the daytime and most of the others are very shy of man, and hide and keep still and quiet as soon as he approaches. This is not true of the long-tailed parraquets which swarm in every jungle in noisy, screeching flocks, and form one of the most characteristic features of an Oriental landscape. In many parts, too, the diurnal butterflies, many of them very large and beautiful, are conspicuous. The universal presence of ants will also soon be brought to one's attention together with the fact that many of them sting. Leeches are equally obvious and unpleasant in the dripping rain forests.

The presence of some of the animals may be detected by the characteristic noises they make. The weird unearthly howl of the jackal at night and the rollicking whoops of the gibbons in the early morning or evening are sounds which are almost impossible to describe, but once heard are not likely to be forgotten. Another noise which may be heard from a mile or more away is that made by the great hornbill beating the air with violent strokes of its ponderous wings. The shrill cries of many species of gecko are very entertaining when first heard, but the never-ending repetition of the same two syllables can become exasperating where a noisy species is numerous. Very curious is the noise made, surprisingly enough, by the pupa of a butterfly of the genus *Gangara*; the caterpillar of this insect coils a leaf into a tube which it lines with silk and then pupates inside. The pupa is firmly attached by the tail and, when disturbed, shakes itself violently up and down as well as sideways to produce a loud and very rapid resonant rattle. Not content with this the pupa will also hiss if touched.

From these remarks of a general nature we will now turn to a description of some of the more conspicuous or otherwise interesting features of the animals, starting with the anthropoid apes and working down the animal kingdom until we are overwhelmed by the wealth of insects and other invertebrares.

The gibbons (*Hylobatidae*) are the only man-like apes found in Burma as the orang-utan does not extend outside Sumatra and Java. Gibbons are the smallest of the anthropoid apes, and stand only 30 inches or so high. In some ways they resemble man more closely than other apes. The nose and chin are well developed, and the forehead is smooth and upright and lacks the prominent eyebrow ridges of other apes. Although the arms are so long that they reach the ankles they are not used on the ground, but are held up in the air while the animal walks quickly and easily in a perfectly erect manner. Gibbons are found in hill-forests anywhere east of the Bay of Bengal. They are noisy gregarious animals living in troops of anything up to 50 or 100 individuals. Gibbons are thoroughly arboreal and may be described as the master gymnasts of the jungle. Their long arms and light bodies enable them to swing themselves for great distances from branch to branch and from tree to tree. They ascend hills rapidly, swinging themselves up in this way; and they come down again at an astonishing pace by hanging on to bamboos or branches that bend beneath their weight carrying them down to grasp the tips of others lower down the slope for another mighty downward swing. Gibbons are very delicate and rarely live long in captivity; but, when captured young, hoolocks are easily tamed and make very gentle, good-tempered, cleanly and exceedingly intelligent pets. There are many species of monkey, mostly macaques like the pig-tailed monkey and the crab-eating monkey, and also langurs or leaf monkeys. The crab-eating monkeys are found on the banks of tidal creeks where they live on seeds, crustacea and insects; they swim and dive well.

Lemurs may be distinguished at a glance from monkeys by their foxy, expressionless faces. True lemurs are confined to Madagascar, but related forms are found in Africa and Asia. In Burma there is the slow loris, *Nycticebus*, a nocturnal animal about the size of a cat, with large circular eyes and short round ears buried in fur. It has a thick coat of very close, long woolly fur, and sleeps by day curled up into a fluffy ball in the fork of a tree, its head and hands buried between its thighs. It rarely leaves the trees and climbs well in a slow, silent, methodical way, one foot at a time.

Carnivores

The tiger is one of the animals most typical of the Oriental Region as it occurs in forests and grass-jungle throughout the area except for Ceylon and Borneo, and outside this area it occurs only in the valley of the Amur and near the Caspian and Aral Seas. It is quite common in the forests of Burma, but not very abundant near the Burma Road. The tiger is a good swimmer but does not climb; it will however sometimes jump at a man in a tree and there is a record of a native pulled from a tree 18 feet from the ground. Tigers are the largest and strongest of the carnivores. One killed in Burma a few years ago had a total length of 10 feet 4 inches. Tigers generally stalk and kill their prey in the daytime, leaving the carcase where it lies and returning to eat it at night. It is unusual for a tiger to leap upon its prey; there is generally a sudden rush and if the animal is large, a bullock, for example, it is seized by the throat and with a sudden wrench its neck is broken, the tiger sometimes jumping right over to the other side of the animal in the act. It is all over in a moment and the tiger is often back among the bushes before the rest of the herd realise what is happening. Leopards are thoroughly arboreal and particularly fond of eating monkeys and dogs. A panther is only a large specimen of the same species. Other species of cat are too numerous to describe. The clouded leopard is perhaps the most beautiful of the tribe and the fishing cat may be mentioned as an example of the smaller kinds.

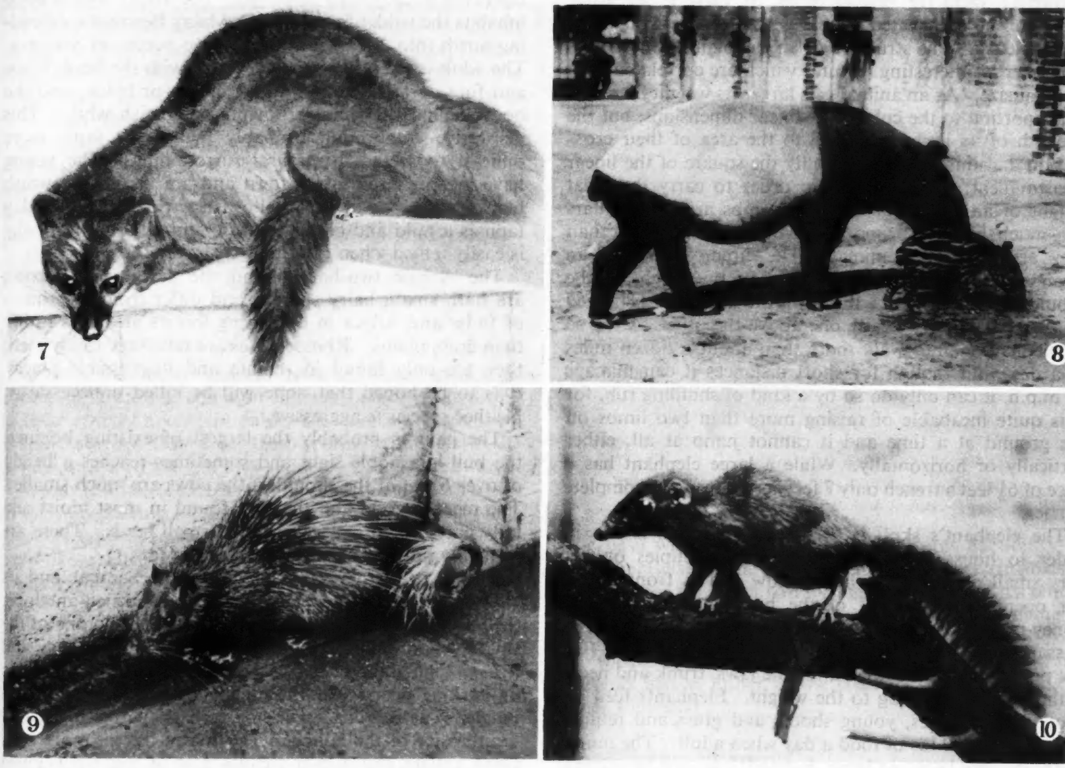


FIG. 7.—The Common Palm Civet—*Paradoxurus hermaphroditus*. (Photograph by W. S. Berridge. From *The Journal of the Bombay Natural History Society*, Vol. 38). FIG. 8.—The Malay Tapir, and young with primitive pattern. FIG. 9.—The Brush-tailed Porcupine. FIG. 10.—A Tree Shrew (*Tupaia*). (FIGS. 8-10, copyright, Zoological Society of London)

Among the dog family the slinking jackal may be seen at dusk in parts of northern Burma and is best known for disturbing the night with its bloodcurdling long wailing howls followed by a succession of quick yelps. There is also a species of wild dog which hunts in packs and is a great nuisance where it occurs.

Civet cats and their allies abound; they feed on birds and small mammals and most of them repel their enemies by producing unpleasant smells (Fig. 7). The mongoose is too well known to need description; there are several species in Burma; they are easily tamed and make charming pets. The varied diet is well shown by what was found in the stomach of one—"a quail, a small wasps' nest, a lizard, a number of insects and part of a custard apple."

Bears are well represented in the region. The Himalayan black bear of the northern forests lives in families and is easy to stalk. When driven from a forest they come out in single file, the largest leading. The Malayan bear is a small bear only about 4 feet long; it has very short black fur and a wrinkled face. It is easy to tame and generally gentle and amusing in captivity.

An interesting relative of the bears is the little panda, *Ailurus fulgens*, which is found in the mountains of the north between altitudes of 7,000 and 12,000 feet. It has long thick fur, bright rusty red in colour, with black underparts, a white face and a long thick, banded tail. The head is broad and round with a very short muzzle and large rounded ears. The animal walks on the soles of its feet like a bear and has sharp, non-retractile claws. It is a good climber; but feeds on the ground and breeds among rocks. The little panda is rather rare, but is sluggish and easily captured. It is a gentle harmless animal and makes an engaging pet; but it cannot endure heat and is susceptible to cold. Entirely herbivorous, it will not touch meat and in the natural state feeds on fruits, nuts and young shoots of bamboo. The giant panda (*Ailuropoda*) of China does not occur in Burma. The family of weasels, stoats, polecats, badgers and otters must be mentioned as there are many species in these parts; but space cannot be spared for their description; in form and habits they are very similar to their British representatives.

Wild elephants are found throughout Burma, in hilly forested country particularly where there is dense bamboo. They are very intolerant of heat and keep near water in the denser parts of the jungle when it is hot. Elephants are very much at home in the water, squirting it over their bodies with their trunks and rolling in the mud. They swim well, very low in the water, with only part of

the head and the trunk out of the water and have been known to swim for several miles. If there is no water available the overheated animal will throw dust or leaves over its back. The structure of an elephant's body shows a number of interesting features which are correlated with its great size. As an animal gets larger its weight increases in proportion to the cube of its linear dimensions, but the strength of its limbs is related to the area of their cross section and this increases by only the square of the linear measurement. Consequently in order to carry the great weight of an elephant's body the limbs are great pillars very much thicker in proportion to the size of the beast than they are in smaller animals. The circumference of an elephant's foot is almost exactly half the height at the shoulder. The bones of the limbs are moreover arranged in a straight line vertically one above the other. Even so an elephant cannot walk more than about a dozen miles in a day, and though for short distances it can manage 15 m.p.h. it can only do so by a kind of shuffling run, for it is quite incapable of raising more than two limbs off the ground at a time and it cannot jump at all, either vertically or horizontally. While a large elephant has a pace of 6½ feet a trench only 7 feet across makes a complete barrier.

The elephant's skull is very large, but this is not in order to house a large brain for this occupies only a very small proportion a little below and in front of the ear openings. The bulk of the high, globular skull is honey-combed with air-cells connected with the nasal passages. In this way a large surface is provided for the powerful muscles needed for the jaws, trunk and neck, without unduly adding to the weight. Elephants feed on roots, twigs, leaves, young shoots and grass; and require from 600 to 700 lbs of food a day when adult. The molar teeth are very large, so large that only one can be accommodated in each jaw on one side at a time. This is pushed out from behind by its successor when worn out. Six teeth follow one another one at a time in each half jaw, and in this way the large grinding area required for so large an appetite is maintained for many years, a century or more. Without these specialisations the elephant would not be able to eat enough to maintain its great bulk, and it is said that 18 hours out of every 24 have to be spent just eating, and the other six are mostly needed for sleep. The intelligence of elephants is often over-rated, but they are very docile and are tamed and trained regularly after capture when fully adult, and this is very rarely possible with other animals. Elephants hardly ever breed in captivity but are thought to do so more often in Burma than in India. At certain periods of the year the male goes "mast" and becomes dangerous; this is probably of a sexual nature. The approach of the attacks is indicated by a copious flow of a dark oily liquid from a small orifice in each temple.

Primitive Ungulates

The tapirs are among the oldest of the living mammals and have rather an antediluvian appearance. They belong to the same section of the Ungulates as the horses but are very much more primitive; there are four toes on each fore foot and three on the hind foot, and the teeth are simple and unspecialised so that like the pigs they have to feed on fairly soft food. The curious distribution of the tapirs has already been described. The Malay tapir (Fig. 8) inhabits the wilder forests of the Malay Peninsula, extending north into Tenasserim and it also occurs in Sumatra. The adult is strangely parti-coloured, with the head, limbs and fore part of the body dark brown or black, and the body behind the shoulders white or greyish white. This disruptive colouration probably makes the tapir more difficult to see in its natural surroundings. The young have a more primitive pattern and are at first brownish black with longitudinal yellowish stripes. The Malay tapir is a mild and gentle creature and although very shy is easily tamed when captured.

The Asiatic two-horned and the Javan rhinoceroses are both small, hairy species, and differ from the rhinos of India and Africa in inhabiting forests and hills rather than grass plains. Rhinoceroses are now very rarely seen; they are only found in remote and inaccessible places. It is to be hoped that none will be killed unnecessarily. Neither species is aggressive.

The gaur is probably the largest of existing bovines; the bull is a noble sight and sometimes reaches a height of over 6 feet at the shoulder; the cows are much smaller. The meat is good and they are found in most moist and hilly parts of Burma, generally in small herds. There are probably no wild water-buffalos left here.

There are many species of deer. The Sambar and its allies are found in the forests. The four-horned antelope, the only living antelope with four horns, is also one of the smallest and has the habits of a hare. It is solitary and lives in long grass or low bushes near water. The muntjac or barking deer is another small species found in thick jungle. The call is a single hoarse bark, surprisingly loud for the size of the animal. The males have simple two-tined antlers and also a vicious pair of tusks developed from the upper canines. The flesh is excellent.

Mouse Deer

The chevrotains or mouse deer are interesting little animals with a number of primitive features. The stomach instead of having four compartments like the true ruminants has only three, and each foot has four complete digits, though two of them do not reach the ground. Other primitive features are the presence in the male of long upper canine teeth, which project below the mouth, and the absence of antlers. Most of the early deer were without antlers but had tusks, and this is also the case with the Chinese water deer and the Himalayan musk deer. Chevrotains were once more widely distributed but they are now confined to West Africa and the Oriental Region. In form and size they look rather like rodents. The smaller of the two species found in Burma is only about ten inches high at the withers. The popular idea that they have no joints in their limbs has arisen from the peculiar mincing way of walking on the extreme tips of the hoofs.

The wild boar found in bamboos or bushes or in the forests of Burma is related to the European species and has the same destructive habits and fierce disposition.

The dugong, *Halicore dugong*, may be seen in the estuary of the Irrawaddy and other large rivers; its range extends from the Red Sea to the coast of Australia. The dugongs together with the manatees of the tropical Atlantic are

placed in a separate order of mammals, the Sirenia. Superficially they have some resemblance to the whales but have no real affinity to them. They are completely aquatic animals and never leave the water except when accidentally stranded. They are gregarious and browse under water on seaweeds and other plants, coming in to feed with the flood tide and returning with the ebb. Their thick, mobile lips are furnished with bristles, and they have claws on their flippers. They suckle the young from teats on the breast. The slight resemblance to a human figure with a fish-like tail has no doubt given support to the belief in mermaids; but certainly they did not originate the myth which is very much older than any European knowledge of the animal.

Burmese Rodents

Among the many rodents two or three species of porcupine are quite common in rocky places, but owing to their strictly nocturnal habits they are not often seen. When disturbed they erect their spines, grunt, rattle the hollow quills on the tail and suddenly charge backwards. A favourite trick of theirs is to dash between a man's legs in this way leaving a few of the rigid spines of their hindquarters embedded in his calves. The excellent veal- or pork-like quality of the flesh is well known. One Burmese species, *Atherura macrura*, is not as spiny as are species of *Hystrix* and it has a long tail ending with a tuft of curious bristles, flattened at intervals to give a string of little discs (Fig. 9).

The Indo-Malayan region seems to be the centre of distribution of the world's squirrels. There are more species here than anywhere else, and they reach their maximum size and have the most striking colours, too. One species, *Ratufa gigantea*, has a head and body measurement of about 16 inches, and a tail 20 inches long or more.

The distribution of the various species is very interesting; for example the Chindwin River forms an almost complete line of demarcation between 8 species and subspecies along the west bank and 15 on the east bank. Except for *R. gigantea* on both sides of the river near the source, where it may have spread round, and one species which has crossed at Homalin, perhaps with native help, no species or subspecies occurs on both banks of the river.

Two or three genera and several species of flying squirrels are also found here and some of them are even larger than the squirrels just mentioned; one of them, *Petaurista*, (Fig. 11) is perhaps the largest of all squirrels. Other genera of flying squirrels occur in America. Flying squirrels resemble other squirrels in general appearance and have similar long bushy tails. They have a wide membrane on each side, which can be stretched out between the legs and is further supported by a long cartilage extending from the wrist. Membranes between the fore legs and the neck and between the hind legs and the tail are better developed in some species than in others. By spreading the membranes out the animals are able to glide through the air for 60-80 yards. The squirrel leaps from the higher branches of one tree with its parachute extended; at first it loses height rapidly, but then, making use of the resistance of the air, it gradually "flattens out" until the flight becomes horizontal and finally ends in a short ascent to the trunk or branch of a tree.

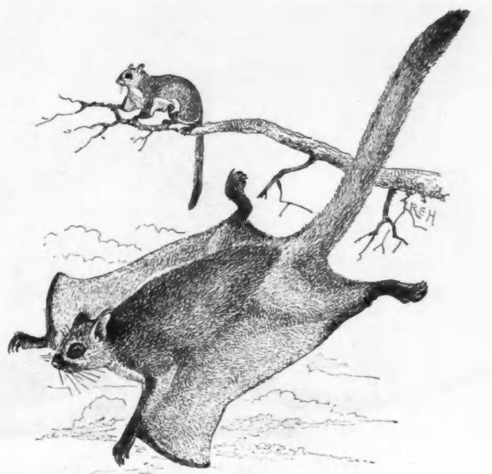


FIG. 11.—A Flying Squirrel (*Petaurista*). (From *The Fauna of British India*)

The ease with which they alight indicates an ability to steer themselves in the air. Flying squirrels sleep in holes of trees, curled up into a ball during the day. The parachute is not very conspicuous when the animals are not flying as it contracts of its own elasticity, but it does seem to impede the movements to some extent as flying squirrels are not quite as active, either in the trees or on the ground, as other squirrels.

The Flying "Lemur"

This is a convenient place to describe *Galeopithecus*, the colugo or flying "lemur". (A drawing of it appeared on p. 218 of the last issue of DISCOVERY). This remarkable animal is generally placed in an order by itself, the Dermoptera, as its relationships with other mammals are rather obscure. Generally considered to come nearer the Insectivora than anywhere else, it certainly has nothing to do with the lemurs. The parachute is very well developed and takes in the long and prehensile tail and is even extended as a web between the toes. While not a true flyer in the sense that a bat is, *Galeopithecus* loses less height and sails through the air for greater distances than the flying squirrels can. Using its short, strong fingers and sharp claws it climbs to the top of a tree, and after launching itself in the air it is able to control the direction of its glide so as to alight on the trunk of an isolated tree 200 feet or more away; in this distance it will only lose 30 to 40 feet in height. *Galeopithecus* is also remarkable for the structure of its teeth. The lower incisors are unlike those of any other animal and resemble little combs standing on narrow pedestals. The coluga differs from the Insectivora in feeding on leaves. It is entirely nocturnal and remains hanging on a shaded part of a tree during the daytime, its peculiar mottled colouration matching the bark so that it is not easy to see.

In addition to the innumerable species of insectivorous bats in Burma there are the large fruit bats or flying-foxes which feed on fruit; there are also the false vampire

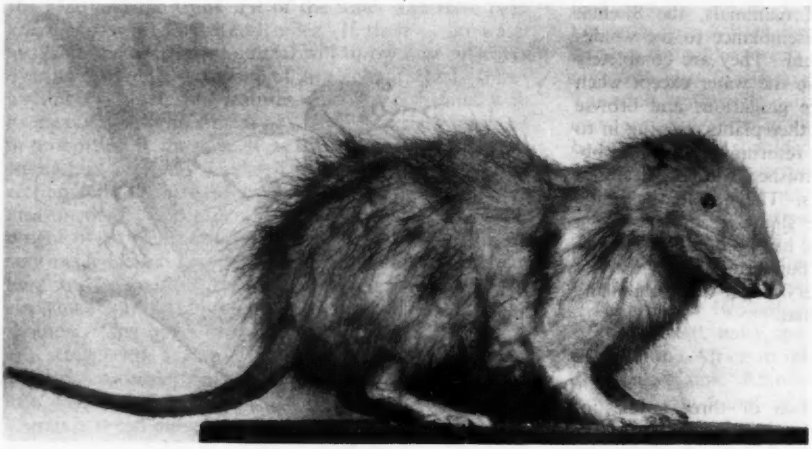


FIG. 12.—A Spineless Hedgehog (*Gymnura*)

bats, *Megaderma*, that live on other bats, frogs and sometimes fish and which have large ears joined at the base. The Malay flying-fox, *Pteropus edulis*, has a wing span of 5 feet and is the largest bat known. It occurs in the Malay Peninsula and the islands and may extend into Tenasserim: but the flying-fox which is common in Burma is the Indian species, *P. medius*, with a wing span of 4 feet. At dusk singly they fly long distances to fruit, but they congregate in enormous numbers.

In addition to familiar forms like moles and shrews the Insectivora of Burma include *Gymnura* (Fig. 12) which takes the place of the hedgehog and is in fact a long-tailed, spineless hedgehog, and the tree shrews, *Tupaia* (Fig 10). The gymnuras have the same nocturnal, insectivorous habits as the hedgehogs, and structurally they are similar but the absence of spines makes them look very different. They make up for the lack of prickles by having an offensive smell which has been described as being like an Irish stew gone bad. The Tupaiidae, although confined to the Oriental region, are very well distributed through it (see Fig. 1, p. 217, of previous issue). They are arboreal, shrew-like insectivores with long bushy tails, and look very much like little squirrels with long noses; they have a similar habit of sitting up holding their food (of insects and fruit) to the mouth. They are active in the daytime; often in the dry season they come indoors and become very tame.

The Pangolin

Two species of Pangolin, or scaly ant-eater, *Manis*, occur in Burma (see Figs. 4 and 5, p. 220 of previous issue). The curious large horny scales overlap like those of a spruce fir cone and give the animal rather a reptilian appearance, but the belly and spaces between the scales grow hair like that of ordinary mammals. The animal is nocturnal and feeds on white ants which it digs up with its powerful claws and captures with a long sticky tongue; it is quite toothless. When disturbed it rolls itself into a tight ball which it is almost impossible to unroll, so muscular is the animal.

Birds and Reptiles

The birds are so numerous and varied that we shall have to confine ourselves to a very small proportion of them. The sun-birds (Nectariniidae) with their bright metallic colours and long slender bills and their habit of sipping nectar from blossoms are rather like humming birds. The minivets, of which there are many species, are a constant source of delight in the forests and are remarkable for their brilliant plumage with red and yellow predominating. They are usually seen in parties, flitting from tree to tree in follow-my-leader fashion and keeping together with soft and musical call-notes.

The broadbills belong to a family of birds, the Eurylaemidae, which is confined to the Oriental Region, (Fig. 1, p. 217 of previous issue) though it may have been more widely distributed in the past. Most species are brightly coloured and they can readily be distinguished by the very wide base of the upper mandible, often broader than the head (*see* Fig. 13). The pittas (Pittidae) are thrush-like in their build and habits, hopping about on the ground beneath dense jungle as they search for insects, but no thrush has such lovely plumage of crimson, blue and other gay colours. The largest of the hornbills, *Dichoceros bicornis*, inhabits hilly country throughout this region: it is nearly five feet in length, and has a great bifid casque above its bill. The female hornbill remains imprisoned in a hole in a tree while she incubates the eggs, and during this time she is fed by the male. The entrance is plastered up with mud except for a small opening through which the food is passed. As decaying vegetable matter and the bird's own droppings are incorporated in the plaster the nest is often a filthy stinking affair. The ubiquitous parraquets, of which there are many species, have already been referred to. Related to them are the curious little brightly-coloured hanging parrots which sleep head downwards suspended by the feet. The red jungle-fowl, *Gallus gallus*, from which has descended the domestic game-cock which it resembles, is common in the wet jungle. The Argus pheasant, *Argusianus*, and the peacock, *Pavo*, are among the larger of the spectacular birds found in the area. The male Argus Pheasant spreads its wings into a fan with eye-like markings similar to those of the peacock. They are solitary birds; each male has its own "drawing-room"—an open level piece of ground in the depth of the forest, six yards or more across from which all weeds and dead leaves are removed. The smooth bare earth remaining is kept scrupulously clean.

The crocodiles and their allies are the most highly organised of living reptiles and in some respects they approach the birds; for example, the heart is divided into four separate chambers so that arterial and venous blood

are completely separated, as in birds and mammals. Their special adaptations to aquatic habits include movable lids to their ears, and the way the top of the windpipe fits into the back of the nasal passage so that the animal can drown its prey under water; its mouth can be full of water yet it can breathe at the same time. The mugger, *Crocodilus palustris*, is the commonest species in Burma and reaches a length of 12-14 feet or more. The estuarine crocodile, *C. porosus*, is a large and dangerous species confined to the tidal parts of rivers. Specimens have been known to reach a length of 33 feet. The gharial, belonging to the distinct family Gavialidae, may be distinguished at a glance from the true crocodiles by the very long and narrow snout; it feeds almost entirely on fish, and though it reaches a length of 20 feet it is of a harmless disposition. The family is confined to the Oriental region and is found in many of the rivers of Northern India, and in the Malay Peninsula, Sumatra and Borneo; except for the Koladyni river it seems to be absent from Burma.

Tortoises and terrapins abound. The Burmese brown tortoise, *Testudo emys*, reaches a length of 18 inches and is found in moist wooded regions. There are half a dozen species of hinged terrapin; these derive their name from the ligamentous hinge across the middle of the lower shield that enables the hinder aperture of the shell to be closed. The batagurs are large fresh-water tortoises which abound in the rivers of India and Burma, their shells, 20 or more inches in length, being conspicuous objects as the reptiles come up to breathe. One of the most extraordinary looking animals is the big-headed tortoise, *Platysternum megacephalum*, which has a flat, oval shell about six inches long, a long tail and an enormous hook-beaked head. This is the sole representative of another family confined to the Oriental region, the Platysternidae (see map on p. 217 of previous issue). Indian and Burmese bathers are often bitten by soft tortoises, fierce little animals with the neck vertebrae specially shaped so that the head can be darted out with extraordinary rapidity. The carapace lacks some of the marginal bones and passes at its borders into a soft expansion of skin; the lower shell is incompletely ossified and separate from the upper one; all species are thoroughly aquatic.

Among the innumerable species of lizard are a great many geckos inhabiting a great variety of terrestrial and arboreal environments; several species come into houses. Their nocturnal habits and weird cries, coupled with their curious disc-like sucker toes enabling them to run along ceilings, may be responsible for the superstitious dread they inspire in many people. They are however innocuous, fascinating little creatures, those inhabiting houses frequently becoming quite tame. During the daytime geckos remain concealed among stones or in crevices of trees. Lying motionless they are very difficult to see as they match their surroundings very closely in colour and pattern, and their squat bodies enable them to flatten themselves against the background so that little shadow is cast by their bodies which seem part of, and continuous with, their surroundings. The fringed geckos, *Ptychozoon*, sometimes called the flying geckos, have a flap of skin along the flanks continued as lateral expansions of the tail; these were formerly thought to act as planes for parachuting: but it has been suggested that their main function is for the concealment of shadows. This may give us a clue to the origin of the gliding habit of so many animals in this part of the world; for it is difficult otherwise to see how flying membranes could have arisen as in the early stages they would be useless for gliding. Unfortunately very few zoologists have had the opportunity of studying living fringed geckos and more information about their habits in natural conditions would be welcome. The flying dragons, of which *Draco volans* is the best known of several species, range over most of the Oriental region. These animals do use the large wing-like expansions to glide from tree to tree. The flying membrane is supported on the elongated extensions of some of the hinder ribs, and when not in use is folded to the sides like a fan. These lizards are exquisitely coloured with bright metallic patches of colour mingled with dark spots or bands on the back. The parachute is brilliant red, orange or yellow according to species. In spite of the bright colour the lizard is very inconspicuous in its natural surroundings as it lies in the shade along the trunk of a tree, for then the parachute is folded and almost invisible and the colours on the back seen from a short distance away become mingled to give a mixture of brown and grey very similar to the bark. This lizard carries the art of camouflage farther than this, for when it is gliding through the air the bright colour of the parachute is displayed and catches the

FIG. 13.—The Rufous-necked Hornbill (*Aceros nepalensis*). From a drawing by H. Grönvold.

eye, only to disappear suddenly at the same instant as the the animal alights and movement ceases. There is an almost irresistible illusion that the lizard must have glided on beyond and behind the trunk of a tree when in fact it has alighted on the side in full view.

The monitors are large lizards four or five or more feet long. They are active carnivorous animals, found as a rule near water. They are often incorrectly referred to as iguanas which are tropical American lizards resembling them in size but little else. The great water monitor, *Varanus salvator*, reaches a length nearly of seven feet and is common in hilly marshy country ranging from India through the Malay region and China to Australia. Its flesh is edible and its eggs fetch a better price in Burma than do those of hens.

The snakes are as numerous as the lizards but usually less conspicuous. There are large non-poisonous pythons and boas. The agile whip snakes, *Dryophis*, twine their slender bodies round trees. Most of the poisonous snakes, such as the cobras and vipers, are ground living; an exception is the genus of climbing tree-viper of India and Burma, *Trimeresurus*, with a very prehensile tail. Many of the arboreal snakes are green in colour.

Of the amphibia the most interesting are perhaps the flying frogs, *Rhacophorus*, of which there are 40 or more species in South and East Asia and Madagascar. The toes are very long and fully webbed in most species so that when expanded they provide a surface much larger than that of the body and enable the frog to sail through the air (Fig. 14).

Of the fishes of Burma we shall only mention the large-scaled barbels (*Barbus tor*), the celebrated mahseers of sportsmen, and also the so-called climbing-perch, *Anabas scandens*, which travels long distances on land, hitching itself along through grass and other herbage with its fins.

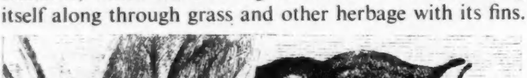


FIG. 15.—Leaf Butterflies (*Kallima*) in flight and repose.

FIG. 14.—Flying Frog (*Rhacophorus*). From Wallace's *The Malay Archipelago*.

In *Anabas* there is a cavity over the first gill arch with an elaborate arrangement of thin plates of bone for holding water and this makes it possible for the fish to respire when out of the water.

Apart from the large and beautiful butterflies and the ants already referred to, the most noticeable of the insects are perhaps the flies, many of them bloodsuckers that transmit diseases. Some of the examples of cryptic colouration among the insects are extraordinarily effective for their purpose. In many of the praying mantises both the form and the colour are combined to produce a striking resemblance to natural objects in their surroundings. Many are stick-like; others living among grass are slender and green or "dry grass colour". Some look like leaves and sway themselves gently from side to side as if moved by the breeze. The orchid mantis, *Gongylus*, is one of the most remarkable; the upper surface mimics an orchid flower so that it escapes the notice of its enemies, and when it arranges itself in a particular way its lower surface suggests a blue flower so that insects are attracted within range of the forelegs and then captured. Another beautiful example of camouflage common in Burma is provided by species of the butterfly *Kallima*, a genus related to the Purple Emperor of Britain. Rich colouring including purple and orange adorns the upper surface of the wings, but the under surface is quite different and in the resting attitude is almost exactly like a dead leaf in shape and colour, with stem, midrib, and lateral veins all accurately represented (Fig. 15). Here we have another example of "flash" colouration. The eye is deceived by the dazzling colours flaunted before it by the insect while it is flying and difficult to catch; then in an instant, the quick-change artist discards its flashy suit, and remains motionless and indistinguishable from the dead leaves among which it has settled. Wallace in *The Malay Archipelago* gives a vivid account of the way this butterfly deceived him as well as describing many other animals that he was the first European to see.

Power for the Highlands

A NEW APPROACH TO REGIONAL DEVELOPMENT

THE North of Scotland Hydro-Electric Board was established in 1944 to develop the water power resources of the Scottish Highlands. The Board proposes to examine 102 power projects which are estimated to have an ultimate annual output of about 6,274 million kWh. An equivalent output of electricity from coal-fired stations would consume 4,000,000 tons of coal.

The population of the Highlands has been steadily decreasing in the last sixty years. There has been a drift of population to industrial areas outside the Highlands in search of an improved standard of living because there are no prospects in the crofts and villages of this undeveloped northern region. When cheap supplies of electricity become available, through the North of Scotland Hydro-Electric Board, it will be possible to establish new industries and extend the amenities of the Highlands.

There are already hydro-electric schemes in Northern Scotland which are run by private companies, but these have brought little benefit to the Highland people. This is because power generated in the Highlands is transmitted to industry in Central Scotland. It is also used in isolated industrial projects in the Highlands, such as that at Kinlochleven which was established by the British Aluminium Company. There a community has grown up which is entirely dependent upon a single industry and no opportunities have been provided for the inhabitants to enjoy an adequate measure of decent communal life. Therefore, the problem to be solved, if prosperity is to be created in the Highlands, is not simply one of creating new industrial centres but one of how to raise the standard of living throughout the region.

The Hydro-Electric Board has the responsibility of generating and transmitting electric power, but the Board has not been granted powers to determine how the energy shall be utilised. The need for planning electric power production and transmission is now generally accepted, but the need for planning the utilisation of power in the social interest has been almost entirely overlooked in Britain. Here we have been content to focus our attention on planning on only one aspect of power development.

A report* by a group of members of the Association of Scientific Workers, assisted by two architects, outlines a plan for the production of electricity as an integral part of a general plan for improving conditions in the Highlands. The report represents an important advance in planning literature. It is the first British publication to present a plan for the utilisation of power for the development of natural resources according to the social requirements of the population on a regional basis.

The principal raw materials in the Highlands are limestone and dolomite. These materials can be used for the manufacture of calcium carbide and magnesium metal respectively. The report considers that the future development of the Highlands is largely dependent upon the establishment of these two industries in the region, located where the sources of power and raw materials are in close proximity. Magnesium should be manufactured in Easter Ross, in the Cromarty Firth coastal area, and carbide in the Caledonian Canal region. It is estimated that carbide production should reach an annual output of 280,000 tons, for which one-fifth of the power generated in the Highlands would be consumed, and that an annual output of magnesium of 30,000 tons (consuming one-tenth of the total power generated) would be practicable. The remaining power should be used for various purposes, including an expanded aluminium industry, synthetic rubber, plastics, and calcium cyanide (a useful fertiliser). These new industries would support three or four new towns, each of 30,000 population. An important section of the report is devoted to the subject of town planning. It stresses the need to provide facilities for civic and cultural amenities. The allied problems of agriculture, transport, and light industry are studied as an integral part of the general plan.

The report gives some information on new electro-chemical and electro-metallurgical processes which could be worked, but points out that much information on these processes is not, so far, available to scientists outside the industries concerned. It is recommended that research in these fields should be expanded, in particular, by setting up a centre for research on carbide derivatives and to establish a Light Metals and Alloys Research Association to provide facilities for the interchange of ideas between the factory and the scientists.

The view is expressed that prosperity cannot be achieved by the creation of a few unrelated industrial projects by private enterprise. The primary purpose must be to bring prosperity—and not only *material* prosperity—to the whole region, which may now be classed as a semi-derelict area. Here is a unique chance to create conditions that will guarantee a high cultural level if present day knowledge is fully used. The document recalls that about £30 million will be expended by the Board on the erection of power plants and this capital will be raised out of public funds and the plants operated on a non-profit basis. Are private industrial interests to be allowed to benefit from the cheap electricity produced by the publicly-owned board in order to set up electro-chemical and electro-metallurgical industries of whatever kind they wish? As the report states: "*There has been sufficient factual evidence in the past for us to assert that lack of planning in the social and economic sphere is disastrous to human well-being in present-day society, and that there is little prospect of attaining social objectives with any assurance or rapidity if these objectives remain secondary to private interests.*" If the Highland people are to reap the full benefit of their water power resources it is considered necessary to have a single body responsible for the development of publicly-owned industries, town planning, etc., vested with powers to function as a Highland Planning Board.

F. HAMLYN DENNIS

* *Highland Power:* A Report on the Utilisation of the Hydro-Electric Power envisaged in the Hydro-Electric Development (Scotland) Act, 1943. Published for the Scottish Area Committee of the Association of Scientific Workers by W. Maclellan, Glasgow; 3*s.* 6*d.*

The Bookshelf

The ABC of Flying. By Lieut.-Col. W. Lockwood Marsh, F.R.Ae.S. (London, Pleiades Books).

One effect of the war has been the remarkable increase in the air-mindedness of the youth of this country. This interest in aeronautical matters is understandable enough when one thinks of the glamour which has been associated with air warfare, but fortunately it is not entirely based on this aspect of aviation. It is, in fact, a genuine desire to understand the scientific basis and technicalities of the aeroplane. For this reason it must be supported and encouraged, not only from the narrow view of providing a source of air crews for the R.A.F., but also in order to give civil aviation a chance to develop to its full power. To satisfy this demand the author has attempted in this book to explain in simple language the principles of flight, and methods of design and production of aircraft.

In such a small volume these subjects must obviously be treated in a brief manner; nevertheless the author has succeeded in presenting a fairly comprehensive picture. Aerodynamics being so essentially a mathematical subject, it is difficult to make it understandable in non-mathematical terms, with the result that the earlier chapters require careful reading. The chapters on engines, air screws, design and construction are extremely lucid and comprehensive, and the inclusion of a section on jet-propulsion brings them right up to the minute.

The outstanding feature of the book is the set of photographs illustrating the text. Photographs of the actual air flow past flat plates, streamlined bodies and cambered aerofoils are reproduced from an Air Ministry training film; these show more of what is happening in a single glance than pages of text could explain. The other photographs, showing various stages of production, are also valuable in making clear to the uninitiated the amazing complexity of modern aircraft.

One criticism is called for: the author in explaining how an aerofoil lifts refers to "the compressed air underneath"; it would be more correct to refer to the air at increased pressure (and hence at slower speed), as it is only at very high speeds of flight that the increase in pressure is high enough to be accompanied by compression of the air as well. Since compressibility is such an important phenomenon, it would be better not to confuse the reader on this point.

Though written primarily for the young, this book can equally well be recommended for the adult who wishes to have a short, but comprehensive, account of aeronautics. It also serves well as an introduction to the more advanced works.

J. Black.

Practical Optics. By B. K. Johnson (London, Hatton Press, 1945; pp. viii + 189; 15*s*.).

This book is mainly concerned with the practical application of the principles of geometrical optics; some applications depending on physical optical principles are briefly described.

The tediousness usually associated with certain parts of this subject is absent from Mr. Johnson's book. The explanation lies mainly in the original method of presentation: an outstanding example of this is the method (described in Chapter I) of illustrating the laws of geometrical optics; the large number of well-executed diagrams also add interest to the work.

One part of the book deserving particular attention is the note on pp. 184–6 on sign convention. As one for whom Mr. Johnson's system "met with success in dispelling confusion", the reviewer most heartily recommends it.

The book touches on several important modern developments of the subject. Probably the most far-reaching of these is the electron microscope described on pp. 96–101; there is a photograph of the instrument used at the Royal College of Science and a photograph ($\times$ 11,500) of zinc oxide particles taken with the instrument. So far, only a tenth of the theoretical resolving power has been attained in practice but even so the resolving power is 40–50 times that of the visual microscope; hence, as Mr. Johnson points out, the electron microscope is a most valuable tool. It is, moreover, in all probability, capable of great development. Another modern development—ultra-violet microscopy—is described on pp. 92–96; microscopes operating with wavelengths between 2,000 and 3,000Å are firstly dealt with; a description of the vacuum-enclosed instrument for operation between wavelengths 1,000 and 2,000Å then follows; the gain in resolution is discussed. The author also describes the deposition of non-reflecting films on glass; the striking effect of the technique is illustrated by photographs of apparatus before and after treatment.

The inclusion of an excellent chapter on the working and testing of optical glass is another original feature of the book. There is also an appendix containing much useful practical information.

There is very little to criticise in the book: the section on p. 12 on lens aberrations may be somewhat obscure until Chapter III has been read but this is a minor point. There is no doubt that the book will be of great use to teachers of optics, research workers and users of optical instruments; it will admirably meet a long felt need. M. P. Lord.

Tempo and Mode in Evolution. By George Gaylord Simpson. (Columbia University Press, 1944; Humphrey Milford, Oxford University Press; pp. xviii + 237, 36 figs., 15 tables; 23*s*. 6*d*.).

In their views concerning modes of evolution, a wide rift has existed between palaeontologists and geneticists for many years. It was the consequence of diametrically opposed approaches to the common problem, and eventually the two groups of scientists almost ceased to know each other. Not long ago, a palaeontologist was inclined to regard a geneticist as "a person who shut himself in a room, pulled down the shades, watched small flies disporting themselves in milk bottles, and thought he was studying nature". On the other hand many a geneticist believed (some may still believe) that a palaeontologist "is like a man who undertakes to study the principles of the internal combustion engine by standing on a street corner and watching the motor-cars whizz by".

In recent years, however, attempts have been made repeatedly to combine the results of both parties, as for instance by Schindewolf in 1936, but none has been as comprehensive as G. G. Simpson's *Tempo and Mode in Evolution*. Written by an expert vertebrate palaeontologist who has taken considerable pains to study the results of research in genetics, this book is based on what, in the reviewer's opinion, is the only feasible basis for a real synthesis of evolution, namely chronology—the study of the actual time-rates of evolution as revealed by palaeontological evidence. In his introductory chapter, Simpson demonstrates some rates of genetically linked as well as independent characters and shows how to distinguish these. Here, as elsewhere in the book, the lineages of the North American horses provide much of the author's evidence.

The bulk of the book is devoted to the "modes" of evolution. Variability, mutation rate, character of mutations, length of generations, size of population, and selection are regarded as the most important factors that may influence the course of evolution. Special attention is paid to the discontinuities of the palaeontological record, and to their interpretation, and an explanation is attempted of the known systematic discontinuities which differs considerably from that given by Goldschmidt some years ago. Simpson points out that what Goldschmidt calls Micro- and Macro-evolution in reality belong closely together, but that there is a different mode on a much higher systematic level than any considered by Goldschmidt, and this he calls Mega-evolution.

Simpson then proceeds to study the phenomenon of low-rate and high-rate lines. He describes the phenomenon (with which many palaeontologists have been familiar) that apparently all low-rate lines evolved at one time in the distant past at very fast rates. He suggests that they happened to become adapted to an environment continuously accessible, or to an ecological position varying only slightly in the course of time (involving close adaptation and low tolerance), or to an ecological position varying periodically (involving adaptation with a wide range of tolerance). In such conditions almost all mutations are disadvantageous and tend to be eliminated by selection pressure.

A chapter is devoted to orthogenesis or, as Simpson prefers to call it, inertia in

evolution. He does not find good evidence that a trend has ever continued by sheer momentum beyond a point of advantageous or selectively neutral modification, although the tendency of lines to evolve in much the same direction for considerable periods of time (i.e. orthogenesis in the descriptive sense) is common. Observed orthogenetic sequences are usually most consistent with the view that orthoselection is the primary factor, whilst directed mutation is unlikely to have acted in this manner according to Simpson.

After having discussed the interrelations of organism and environment, and the nature of adaptation, the modes of evolution are summarised. Three types are distinguished which as the author emphasises are not clear-cut. These are: (1) *speciation*, on a low taxonomic level, by branching and adaptation to environmental subzones, (2) *phyletic evolution*, on the middle taxonomic level, with a definite long-range trend often following a shifting path of adaptation, and (3) *quantum evolution*, on a high taxonomic level, with pre-adaptation and rapid shifts to new environments.

Apart from its actual subject matter, Simpson's book is valuable as a critical discussion of the several theories which have been put forward by Goldschmidt, Schindewolf, Willis and others. It is a well-considered and carefully prepared treatise which requires careful reading. It is, however, not easy to read, for the simple reason that when breaking new ground cautious wording is imperative and, as every writer knows, cautious wording usually makes for difficult reading.

It does not matter whether or not one agrees with every one of the author's interpretations but one will always find that his views are based on evidence. An inevitable difficulty is that geneticists will be liable to underrate the weight and abundance of palaeontological evidence available (which cannot be given in full in any book of this kind) and that many palaeontologists will wish they had read an introduction to genetics before they embarked upon reading Simpson's book. It is to be hoped therefore that this new "synthesis" will encourage both palaeontologists and geneticists to make themselves increasingly familiar with the evidence and methods used on the other side of the fence—the surest way towards breaking it down altogether.

F. E. ZEUNER.

The Structure and Reproduction of the Algae. (Vol. II). By F. E. FRITSCH, F.R.S. (Cambridge University Press, 1945; pp. xiv + 939, 2 maps, 336 text-figures; 50*s*.).

THE development of botany in this country has been hindered, and is still hindered, by the lack of up-to-date and authoritative books in English dealing fully and critically with the various groups which make up the plant kingdom. We need these books in two sorts, namely comprehensive impartial accounts setting out what is known about the plants, and also detailed systematic treatises on the lines of the well-known *Süsswasserflora* from which the student can name the plants he finds or else satisfy himself that the plant he has before him has not hitherto come under the notice of a botanist. At present there are few books of either kind to be had in English. A number of the books in current use are out-of-date and others can hardly be put with confidence into the hands of the undergraduate student who is working through the final years of his training, because of the partial spirit in which they are written. If plants are to be named, undergraduates, and more particularly postgraduate students must, for the lower plants, go either to books in German or else spend much time searching through masses of original papers. The regrettable lack of reliable general accounts discourages undergraduate students (and must give them unfavourable ideas of the state of British botany).

Now, and for some years to come, we shall not lack a good general survey of the Algae. In 1935, the Cambridge University Press brought out the first volume of Professor Fritsch's *Structure and Reproduction of the Algae* in which he gave a modern treatment of the Chlorophyceae (green algae) and of most of the smaller divisions of algae. His second volume, now available to us from the same publishers, describes the Phaeophyceae (brown seaweeds), Rhodophyceae (red seaweeds) and Myxophyceae (blue-green algae), and completes the great task the author set himself over fifteen years ago. The book will serve undergraduates and postgraduates alike as a general survey of the algae, and will serve them well; maybe it will stimulate some author or authors to produce a systematic book of equal value.

Although Professor Fritsch is mainly concerned with the form and life-histories of the algae, and therefore with matters which could be dealt with from the laboratory standpoint, he presents the plants in the way in which he has always borne the algae in mind—as living things with work to do, not as dead things dried on a herbarium sheet or embalmed in Canada balsam for inspection under the microscope. His foreword, all too brief —maybe we may hope for an amplification of this at some future time—sets out something of the biology and the geographical distribution of the seaweeds, and it is supplemented in the appropriate places throughout the book by references to matters of biological interest. This insistence, even when only implied, on algae as living plants is what we should expect from the author of so many familiar botanical texts. Without wishing to undervalue the work of those specialists who have trained themselves to work in herbaria with dead plants, we may welcome whole-heartedly this volume instinct with the living plant; it is the study of the living plant which keeps the science of botany alive.

The first book on seaweeds to be published in English was Velley's *Coloured Figures of Marine Plants* which appeared in Bath in 1795, and seems to have been written for the use of the young ladies of fashion of the time, who used some of their leisure in making pretty scrap books of dried seaweeds. From that frivolous beginning we pass by a number of books of very various quality to the volume now before us, a volume which may well stimulate more British botanists to go to the seaweeds. It is curious that in a country with shores harbouring a rich and varied population of plants comparatively little work has been done on those plants by native workers.

The Structure and Reproduction of the Algae is not an easy book to read. It is full of detail, and it demands from the reader some cooperation in sharing the enormous effort the author has put into the preparation of the book. It presents a great mass of facts, no doubt selected facts, but selected in such a way as to show that the author is concerned more with critically covering the field of knowledge than in establishing points of view. By that method he has successfully avoided the wearying of the reader by special pleading; that is acceptable, for a book about plants must be a book about *plants*, as this is.

As many students of the algae know too well, the original literature about the seaweeds, and especially about the red seaweeds, is often very difficult to read sometimes because of the obscurity of the style of writing, sometimes because of the curious style of drawings favoured by some authors, and sometimes because the complicated reproductive processes of the red algae seem to have an air of unreason. Professor Fritsch has done much to clear up these troubles, both text and illustrations helping greatly. If the reader is willing to work on the book and to try to share the thought of the author, he will get enlightenment.

It is impossible to comment in detail on the crowded contents of the volume, but maybe, in addition to what has been hinted of the satisfactory treatment given to the red seaweeds, reference may be made to the manner in which the author has dealt with the Ectocarpales (another tangle which he has straightened out), with the detailed structure of many of the larger brown seaweeds and with a variety of complicated life histories. On all these matters he has shed light, and the English-reading student has a sure guide among many complexities. References to the literature of the subject are provided on the most liberal scale, and there is good reason to know that these references are trustworthy; for that a special tribute of gratitude is due.

It is appropriate that at a time when most of us are speculating about the economic prospects of the next few years we should be given a sound account of the seaweeds, for these plants may well become very important in the post-war world. Since Stanford did his pioneer work in the latter half of the nineteenth century, a few people have speculated on the economic possibilities of the seaweeds. Now that the daily press have begun to talk about alginic acid and its derivatives, it is likely that general interest in the utilisation of the seaweeds will increase. This utilisation may march with the

chemical exploitation of sea water. Some developments along such lines are much to be desired as a corrective to the great waste from modern civilised communities, which, regardless of the steady depletion of the material lying handy for use, pour sewage into the sea, ignoring the danger of loss of fertility in the soil and the effect of that on crops and on the stocks of cattle. Directly, *The Structure and Reproduction of the Algae* may do little to stimulate immediate action, for it is not a book likely to appeal to the administrative mind, but it will spread knowledge of marine vegetation and we may hope that in due time the spread of this knowledge will lead to action. It may be that the importance of human control of the sea will have far wider significance than the generally admitted value of sea-power in time of war; to the gaining of that control, Professor Fritsch's book may well contribute. B. BARNES.

Common Wild Flowers. By J. Hutchinson. (Pelican Books, 1945; pp. 252; 9*d*.).

THERE have been very many popular books published in this country on the subject of wild flower identification, many of them excellent, and ranging over prices to suit every pocket. Probably, however, there has never been one before so cheap, and so good for the price, as this.

Some of these books have been poorly illustrated or lacking in pictures altogether. Many lack a proper key, so necessary for the beginner who otherwise has to wander through the pictures or, even worse, the descriptions until he finds something like his plant. At the other extreme, we have very ambitious volumes with elaborate, though sometimes most unlifelike, coloured plates; of these the cost is often too high for the average amateur who merely wishes to know the names and interesting features of the common wild plants he comes across.

When we turn to Dr. Hutchinson's book, we see he has avoided most of these errors. As he is a well-known professional botanist and an expert on classification we can rely completely on the technical accuracy of his work. He is, moreover, a true lover of wild flowers, and has been from his youth; he is therefore in a better position to know the needs of the ordinary flower lover than many professional botanists who hardly ever see living flowers (and are often quite ignorant of their popular names).

On browsing through the book one is struck by the particularly clear illustrations. These are a departure from the usual English practice, in that clearness and accuracy have been put before purely artistic appearance. This is the usual Continental practice, and may not meet the approval of all British readers; but the reviewer, and many others, have long felt that this method is the sounder. No one who has seen the wonderfully accurate representations in Hegi's *Flora von Mittel-Europa* will fail to see what I mean, if these are compared with the vague, "artistic", impressionistic plates in some of our books.

The text is very clear and remarkably free from errors for a war-time book. The treatment is up-to-date, and the choice of species particularly good, a few interesting rareties being included as well as the commoner kinds. It seems a pity that all orchids are omitted, as they form such an interesting group; the omission of grasses and sedges, however, is probably a wise plan in a book of this scope. The only real criticism one can make is that the language is perhaps a little too technical at times; however, it is probably sounder to teach people the use of a few technical words than to "talk down" to the reader all the time—by the latter road lies only a cul-de-sac of knowledge.

In short, Dr. Hutchinson is to be congratulated on writing and illustrating (and Professor Salisbury on suggesting) such an admirable little volume, which fills so well a long-felt need for a really cheap layman's flora. FRANCIS ROSE.

Far and Near

U.S. Government's Scientfiic Work

THE expenditure on scientific research and development in the United States is not far short of 1 per cent of the national income. A fair proportion of that expenditure goes into research and development work carried on by Government agencies, and the scale of their activities emerges clearly from a recent "white paper" published by the U.S. Government Printing Office. Entitled *The Government's Wartime Research and Development, 1940-44*, this report to the military affairs of the U.S. Senate gives many interesting details not only about research departments of the Services but also about Government establishments whose present concern with war problems represents a diversion from their normal line of investigation.

Naval scientific work (and this includes routine testing as well as research and development) is organised within five bureaux—the Bureaux of Yards and Docks, Ordnance, Ships, Medicine and Surgery, and Aeronautics. The amounts spent by these bureaux over the five-year period 1940-44 were respectively (in round figures) 1,200,000, 109,000,000 122,000,000, 144,378, and 171,000,000 dollars. (The relatively small expenditure on medicine and surgery is explained, of course, by the fact that the naval medical service takes full advantage of medical research done outside the Navy and concentrates its research on special problems such as the development of personnel selection techniques and the improvement of life-saving equipment.)

The research and development work of the U.S. War Department is highly decentralised and carried out by the various arms of the Services, as follows: Army Service Forces, Ordnance Department, Quartermaster Corps, Chemical Warfare Service, Signal Corps, Corps of Engineers, Transportation Corps, Medical Department, and the Army Air Forces. The Quartermaster Corps alone has seven research establishments (concerned respectively with leather and chemical research, climatic research, subsistence research, mechanical research and research on heavy textiles for tents and other equipment, and packaging research. The Signal Corps operates five laboratories and five field stations, and its civilian establishment includes about 1000 research workers and nearly as many laboratory assistants and mechanics. (The Signal Corps is responsible not only for communications, but also for photographic work, and carries on research and development work in this connection). The Medical Department, which maintains seven research laboratories, is justifiably proud of its research record, for its achievements have benefited the whole world; the "white paper" refers to the investigations carried out under its auspices by Walter Reed and Gorgas on yellow fever, Strong on dysentery, and Russell on typhoid. It is interesting to note that one of its laboratories, the Armoured Medical Research Laboratory, is devoted entirely to studying the needs of tankmen. Under the Army comes the Epidemiological Board comprising 10 commissions that study infectious diseases including influenza. The Chemical Warfare Service is concerned not only with all research and development in connection with such items as incendiary bombs, flame-throwers, smokes for screening, marking and signalling, poison gases, gas masks and the like, but also with developing methods of manufacturing the items used by the Service. This involves in many cases the erection and operation of large pilot plants since many ingredients used in chemical warfare munitions have no counterpart in industry and an entirely new and special design for the manufacturing plants is needed. The research and development personnel of this Service totals over 900 persons, of which about a quarter are research scientists.

Turning from military departments, one notes that the Geological Service employs about a thousand scientists, and the scientific staff of the Fish and Wildlife Service is of the same magnitude. The latter service has its utilitarian side—field studies of the fluctuations in the salmon, pilchard, and oyster fisheries for instance—while investigations are also made of the life histories, habits and distributions

of birds, mammals, reptiles and amphibians, investigations that are prompted by considerations not solely economic. (Employees of the Service vest any patent rights in the U.S. Government, and a light touch is conferred to the report by the mention that the Government, as a result of the inventiveness of members of the Fish and Wildlife Service, now holds rights in an improved method of opening oysters, as well as in a type of commercial fishing trawl that releases undersized fish.)

An article on the organisation of agricultural research we published recently, but one point mentioned in the report was not covered there—the four Regional Laboratories of the U.S. Department of Agriculture. These laboratories (each of them cost about 1,600,000 dollars to erect and equip) are responsible for technological research into the utilisation of agricultural and forest products; there is in addition a Forests Products Laboratory in Wisconsin.

Another important Government agency is the National Bureau of Standards, which is roughly analogous to the National Physical Laboratory in Britain. Its organisation is based upon 9 divisions (electricity, weights and measures, heat and temperature measurements, optics, chemistry, mechanics and sound, organic and fibrous materials, metallurgy, clay and silicate products), all of which are housed on a 68-acre site in Washington. It maintains also two field stations for radio measurements, and seven branch laboratories.

The report contains some useful information about the Office of Scientific Research and Development, of which Dr. Vannevar Bush is director. The O.S.R.D. was set up during this war to "initiate and support scientific research on the mechanisms and devices of warfare"; it was also made responsible for initiating and supporting research on medical problems affecting national defence. Most of the proposals for specific research projects undertaken by the O.S.R.D. have arisen from direct requests of the Army and Navy; the projects that have come from the Services have generally been broad in scope, involving many separate scientific problems. Between June 1940 and March 1944 nearly 1000 such projects were put forward, and upon the recommendation of the National Defense Research Committee or the Committee on Medical Research, these were "farmed out" to the most appropriate laboratories (Government, industrial, and university laboratories). The O.S.R.D. itself does not possess any laboratories, and is responsible for putting research projects out to contract and following up their progress. All contracts provide for the payment of the actual cost of the work, but do not provide for the payment of any profit. The co-ordination of research and development which is made possible by the existence of the O.S.R.D. has proved extremely valuable. The report quotes one instance of this—the development of a simplified process for manufacturing an explosive that has already saved the U.S. Government well over 100,000,000 dollars in outlay on manufacturing equipment and tens of thousands of dollars a day in manufacturing the substance. The usefulness of operational research—the method of "following devices into the field in order to aid in their most efficient use and to learn from combat experience of any needed changes in the development programme"—was recognised by the O.S.R.D. with the setting up in October 1943 of an Office of Field Service directed by Dr. Karl Compton. Within five months it had assembled a hundred operational research workers. In England the Office of Field Services operated through the London office of the O.S.R.D. and in the Pacific it has a branch headquarters in Australia.

The War Production Board's Office of Production Research and Development (directed by Dr. Harvey N. Davis) functions in a similar way to the O.S.R.D., and having no laboratories of its own puts research projects out to contract.

A dozen pages of the report are devoted to scientific and technical research done by the T.V.A. One process perfected by that agency was for extracting alumina from clay. The creation of the T.V.A. chain of lakes has created a substantial problem of malaria control, and research is now proceeding in the hope of finding a more effective anti-malarial than quinine, atebrin (mepacrine) or plasmoquin. Valuable work on the production and utilisation of fertilisers has also been done under T.V.A. auspices.

Appendices to the report give particulars about the Commercial Standardisation Group of the National Bureau of Standards, agreements covering the manufacture of synthetic rubber, patent clauses in contracts of Government employment, and research programmes of the War Production Board. The final section comprises 50 pages of financial data showing income and expenditure of the various Government agencies concerned with research and development. After reading this report, one is prompted to suggest that the British Government, when next it presents a white paper on scientific research, might well follow this U.S. precedent and provide a similar abundance of factual details about research and development under Government auspices.

O.S.R.D. Closes London Office

THE branch of the American Office of Scientific Research and Development in London closed down last month. Started in 1941 under the direction of a 33-year old New York engineer, Mr. B. Archambault, it acted as a clearing house for scientific intelligence passing between Great Britain and America. Through it went many scientific secrets vital to the war effort, including information about penicillin and jet propulsion. Many American experts were brought over here to teach the U.S. Army how to handle the new weapons that were to go into action on D Day, and to work in close liaison with British scientists. Over 600 American scientists visited this

[*Continued at bottom of next page*

Night Sky in September

The Moon.—New moon occurs on September 6d. 13h. 43m. U.T., and full moon on September 21d. 20h. 46m. The following conjunctions take place:

September

2d. 11m.	Saturn in conjunction with the moon,	Saturn	1° N.
3d. 11m.	Venus ,,	Venus	3 S.
4d. 22m.	Mercury ,,	Mercury	4 S.
8d. 00m.	Jupiter ,,	Jupiter	4 S.
29d. 00m.	Mars ,,	Mars	0·2 S.
29d. 20m.	Saturn ,,	Saturn	2 S.

In addition to these conjunctions with the moon, the following conjunctions take place:

September

9d. 12h.	Mercury in conjunction with Regulus,	Mercury	0·3 N.
23d. 19h.	Venus ,,	Venus	0·4 N.

The Planets.—Mercury can be seen in the morning hours, rising at 3h. 51m., 4h. 13m., and 5h. 47m. at the beginning, middle and end of the month respectively. The planet attains its greatest westerly elongation on September 6. Venus is conspicuous in the early morning hours, rising at 1h. 51m., 2h. 28m., and 3h. 07m., at the beginning, middle and end of the month respectively. Mars, in the constellation of Gemini—a little N. of μ Geminorum at the middle of the month—rises at 22h. 42m. on September 1, and at 22h. 10m. on September 30. During the month the distance of Mars from the earth varies between 132 and 114 million miles. Jupiter, about midway between β and η Virginis at the beginning of the month, sets at 19h. 26m. on September 1, and about ten minutes after the sun on September 30, and is not favourably placed for observation. The distance of the planet from the earth is 592 million miles at the beginning of the month and 600 million miles at the end of the month. Saturn, in the constellation of Gemini, rises at 0h. 53m. at the beginning and at 23h. 12m. at the end of the month. On these dates the planet is 902 and 864 million miles respectively, from the earth.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

September	Sunrise	Sunset
1	5h. 11m.	18h. 48m.
15	5h. 33m.	18h. 16m.
30	6h. 00m.	17h. 41m.

September	Moonrise	Moonset
1	—	16h. 15m.
15	14h. 44m.	22h. 38m.
30	—	15h. 50m.

The autumn equinox commences on September 23d. 10h.

M. DAVIDSON, D.SC., F.R.A.S.

JUNIOR SCIENCE

Tomorrow's Weather—I

THERE is a story that a mathematician once asked a meteorologist: "Tell me, when will we get a meteoronomy, a science capable of predicting the weather?" When the other replied that that the science of weather prediction already existed and was called meteorology, the astronomer retorted: "Yes, I know; astronomy began as *astrology*." While it is certainly unkind to compare meteorology with astrology, there is no doubt that we can predict an eclipse of the sun a thousand years from now with far greater accuracy than tomorrow's weather. The reason for this is that, while present day science can assess the factors which influence the movements of the heavenly bodies with considerable accuracy, the factors determining tomorrow's weather are so manifold and so complex that we are barely able to predict in rough outline the weather forty-eight hours ahead.

Now that the weather report has come back into the news, many of you may wonder how the weather man knows on a fine and clear summer evening that there will be widespread rain the following afternoon. For it to rain tomorrow, it means that the air above our heads at that time will have to contain a certain proportion of water vapour, and that its temperature will have to be low enough to cause some of the water vapour to condense into water drops which will fall to the ground as rain. It would be difficult enough to predict the humidity and temperature of the air above us twenty-four hours ahead even if the air did not move in the meantime, but that is what almost invariably happens. So what we really have to know is the temperature and humidity which the mass of air which will have moved to our district by tomorrow afternoon is going to have. In other words, we need to know why and how the air everywhere around our district is moving, how moist it is, and what temperature it has or may acquire. In addition we have to take into account the fact that air is not only liable to move from district to district parallel to the ground, but that it may also move up and down.

On a hot day in summer, when there is hardly any wind and the sky is clear, you may notice that all of a sudden there are heaped clouds appearing, seemingly from nowhere. What has happened is that the sun has been shining on the ground and has heated the air above it. This hot air is now rising; as it does so it expands and cools. By the time a certain height (corresponding to a certain degree of expansion) has been reached, the rising air has cooled so much that the moisture contained in it condenses into small droplets and a cloud is formed. If you watch these fair weather clouds carefully, you will see that they are all flat on the lower side and that they are all at the same height. (They look rather like heaps of whipped cream lying on a flat glass plate.) This is the level where condensation occurs and the clouds you see are just the upper parts of the rising air columns which have been made visible by the droplets that have formed in them. K.M.

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country and these visits, arranged by the O.S.R.D. resulted in a complete exchange of information on every conceivable scientific subject between the American and British experts. Some of the American scientists worked in close collaboration with British scientists on counter measures to the flying bomb, and they also collaborated in the attempts to find an answer to V-2.

Committee on Building Research

THE Minister of Works has appointed a scientific advisory committee to advise on and to suggest lines of scientific re-research; to suggest where this research could best be carried out and to keep it under review; and to advise on the practical possibilities and further development of the results of current research.

The committee is: Professor J. D. Bernal (Physics), Birkbeck College, London University (chairman); Dr. E. F. Armstrong, member of Building Research Board; Professor J. F. Baker (Mechanical Sciences), Cambridge University; Professor P. M. S. Blackett (Physics), Manchester University; Professor W. E. Curtis (Physics), Durham University; Dr. C. C. Douglas, Oxford University, chairman, Joint Committee on Heating and Ventilation (Building Research Board and Industrial Health Research Board); Professor C. D. Ellis (Physics), King's College, London; Professor I. M. Heilbron (Organic Chemistry), Imperial College, London University, Scientific Adviser, Ministry of Production; Professor J. M. Mackintosh (Public Health), London University; Mrs. J. V. Robinson, lecturer in Economics, Cambridge University; Sir Ernest D. Simon, chairman, Advisory Council, Ministry of Fuel and Power; Mr. F. E. Smith, chief superintendent, Armament Department; Professor W. N. Thomas (Engineering), University of Wales; Professor S. Zuckerman, Oxford and Birmingham.

Mr. I. G. Evans, Director of Building Research; Lord Amulree, Medical Officer, Ministry of Health; and Dr. R. S. F. Schilling, secretary, Industrial Health Research Board, Medical Research Council, are assessors. Sir Reginald Stradling is executive officer.

Solar Heat Boiler

THE first Soviet solar heat boiler is being built in Tashkent, capital of Uzbekistan. The boiler, expected to yield 120 kilograms of steam hourly, has a reflector of the parabolic type about 33 ft. wide. These "helio-boilers," as they have been christened, should suit the Central Asiatic Republics, which have ample sunshine for over three-quarters of each year, comments *Soviet War News*.

Scheme for Indian Research Fellowships

IMPERIAL CHEMICAL Industries has offered to the National Institute of Sciences (the Indian organisation with functions resembling those of our Royal Society) the sum of 336,000 rupees—about £25,000—for research fellowships in chemistry, physics and biology, the money to be disbursed over the next 5–7 years Each fellowship, it is proposed, would be worth 400 rupees a month and would be tenable in the first instance for two years, with the possibility of extension up to a total of three years. The fellowships would be tenable at any Indian university or institution approved by the National Institute of Sciences.

Science for the Citizen

AFTER a gestation lasting three-quarters of a year, the B.B.C. gave birth to "Science Magazine" on August 5. Readers will have heard the second edition before this issue of DISCOVERY reaches them, as the programme is broadcast fortnightly on Sundays on the Home Service, with a repeat on Fridays on the Light Programme. The first number of "Science Magazine" was devoted to a discussion of what the producer, Francis Dillon, ought to attempt to cover; we reserve our judgment until we have heard some more typical samples. According to the *Radio Times*, it is hoped to include in each "Science Magazine" a broadcast from a laboratory, an interview with a visiting scientist and a review of recent scientific books. We think a programme of this composition will meet with the approval of the reader who wrote to us suggesting that the B.B.C. needs a "science reporter"—"a man (not an eminent scientist) should visit the great laboratories and write up the work he sees going on. . . . In this way a never-ending and fascinating string of 10-minute talks could be put over—*not* from the scientist's viewpoint but from the citizen's angle." Francis Dillon has a great opportunity to approach science from such an angle, and it is to be hoped that he will enjoy all the scientific co-operation necessary for the full success of what promises to be a most ambitious experiment.

In April we mentioned that the B.B.C. was looking for a scientist to look after educational broadcasts on science. These broadcasts, intended for members of the Services, begin at the beginning of September. The scientist the B.B.C. has chosen is Dr. Archibald Clow, who joins the staff as an assistant producer. Dr. Clow, a chemist from Aberdeen University, is a member of the council of the Scientific Film Association.

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